# APPENDIX H
# RIDERSHIP METHODOLOGY

JACKSON COUNTY

COMMUTER CORRIDORS

ALTERNATIVES ANALYSIS

# MODEL FORECAST METHODOLOGY

October 2011

MARC
Mid-America Regional Council

ESTABLISHED 1826 JACKSON COUNTY MISSOURI

CITY OF FOUNTAINS
HEART OF THE NATION
KANSAS CITY
MISSOURI

KCATA
Kansas City Area Transportation Authority

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## I. INTRODUCTION AND OVERVIEW

The Mid-America Regional Council (MARC), the Kansas City Area Transportation Authority (KCTA), the City of Kansas City Missouri and Jackson County, Missouri have initiated an Alternatives Analysis (AA) for two corridors originating in downtown Kansas City, Missouri and serving areas east and southeast of the downtown area. The East corridor generally parallels Interstate 70 and serves downtown Kansas City, Independence, Blue Springs, and potentially Oak Grove and Odessa. The Southeast corridor generally parallels Missouri Highway 350 and serves downtown Kansas City, Raytown, Lee's Summit, and potentially Greenwood and Pleasant Hill. This AA is being sponsored by a Project Partnership Team (PPT) which includes MARC, Jackson County, the KCATA and the City of Kansas City, Missouri. MARC is a nonprofit association of city and county governments and is the Metropolitan Planning Organization (MPO) for the Greater Kansas City region. The metropolitan area includes two states, nine counties and nearly 2 million people.

This report describes the approach to producing travel demand forecasts in support of the Jackson County Commuter Corridors Alternative Analysis (JCCCA). The modeling will be conducted using an adapted version of the Mid America Regional Council (MARC) regional travel demand model (the regional model) which is modified to include the subject corridor. The model will also be compared to available observed data to establish validity.

This report will provide a description of the corridor (Chapter II) and a discussion of the most important issues facing the model forecasts (Chapter III). The regional model will be described in Chapter IV and Chapter V will describe the model inputs. The adaptation of the model to include the corridor will be discussed in Chapter VI. A list of available observed data for calibration and validation will be described in Chapter VII. The validation process will be described in Chapter VIII followed by a discussion of the forecast application to existing, future no-build, TSM and other build alternatives in Chapter IX.

## II. PROJECT STUDY AREA

### II.1 Study Area

The term "***study area"*** refers to the geographic area for the two corridors being studied. For the purpose of this AA, the model encompasses all of Jackson County, the northern portion of Cass County, the northwest portion of Johnson County, and the western portion of Lafayette County. The physical boundaries of the study area are the Kansas state line on the west, the Missouri River on the north, Missouri Highway 131 on the east, and Missouri Highway 58 on the south. Figure 1 shows the study area shaded in light blue. Since the modeled area will include all of the MARC region, plus Lafayette and Johnson Counties, all trips involved in the corridor will be included.

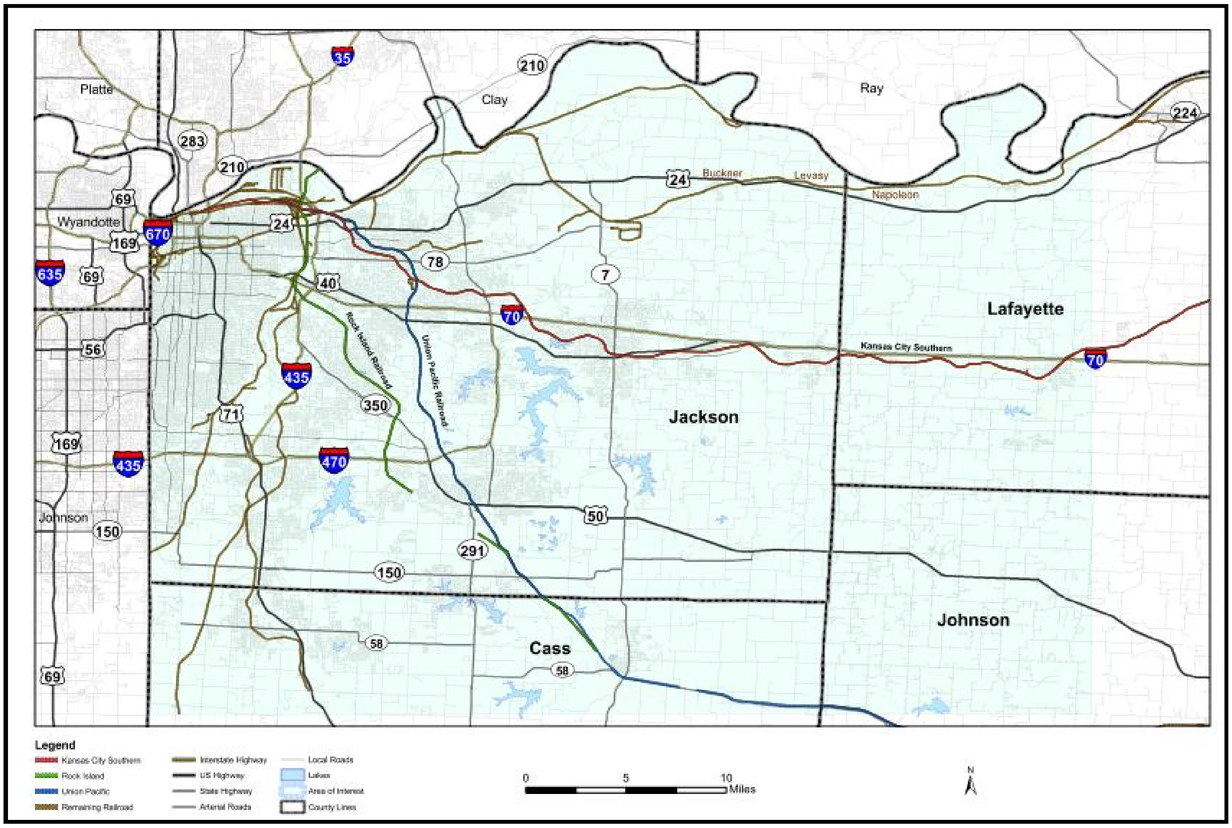



**Figure 1 - Study Area**

### II.2 MODES

Transit modes being considered for this corridor include:

1. Express bus – fast suburban to CBD bus service on freeways or major arterials with local circulation elements or feeder bus support systems. The existing express bus system would be enhanced with greater frequencies and/or increased service area coverage and possibly more daily trips to the new areas.
2. Bus Rapid Transit (BRT) – The BRT mode would make use of existing Rock Island Right of Way, converted to a busway. Operations would be characterized by fast service to the CBD, enhanced and distinctive transit stops, such as is currently used by the MAX system, and specialized vehicles that improve boarding and alighting as well as the passenger ride experience.
3. Streetcar/Light Rail – An LRT or streetcar would serve to connect downtown Raytown and Blue Ridge Crossing with the CBD using an exclusive guideway. Extensions of transit service would be provided by BRT and/or existing express bus service.
4. Regional Rail – A regional rail service would use a commuter rail mode, utilizing Diesel Multiple Unit (DMU) that is FRA compliant. Somewhat higher, all-day frequencies are anticipated as is the use of existing railroad right-of-way where possible.

### II.3 ALIGNMENTS

While final alignments are not set, and initial screening may narrow the selection, the general alignments are as follows:

Figure 2 through Figure 7Error! Reference source not found. shows the current general alignments for these alternatives. Two corridors alignments are being considered known as the east and southeast corridors. For guideway alternatives, the alignment is common between the CBD and the Truman Sports Complex. Differences in alignment are evident for the regional rail alignments, representing different approaches to the CBD.

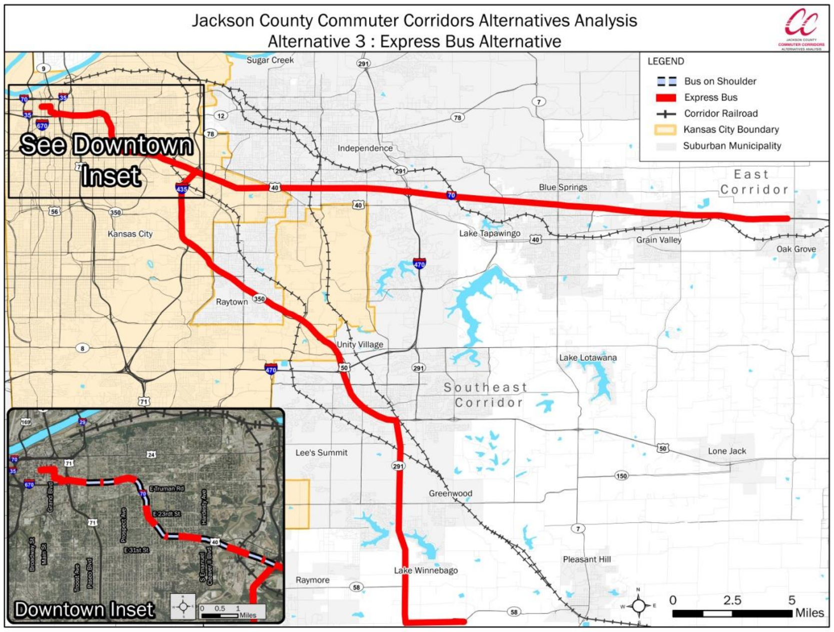



**Figure 2: Express Bus Alignments**

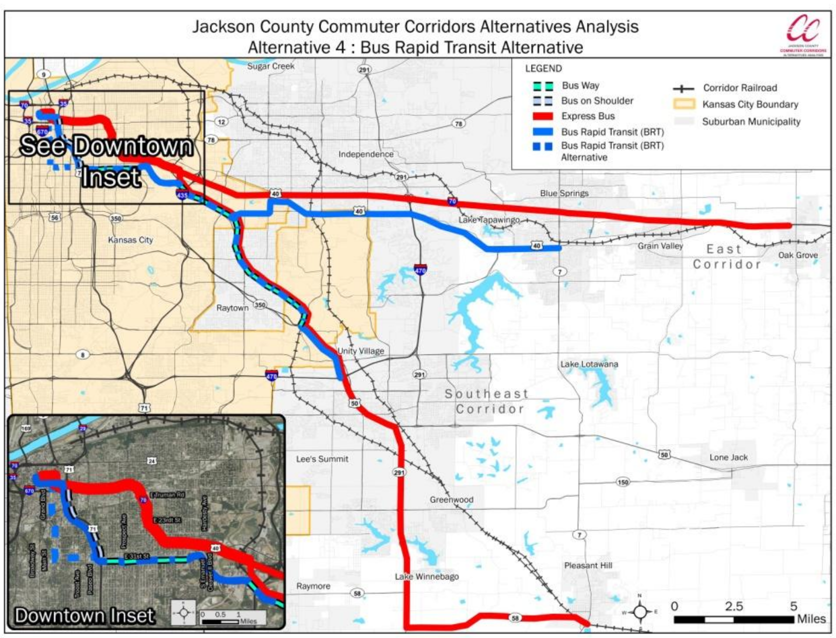



**Figure 3: BRT Alignments**

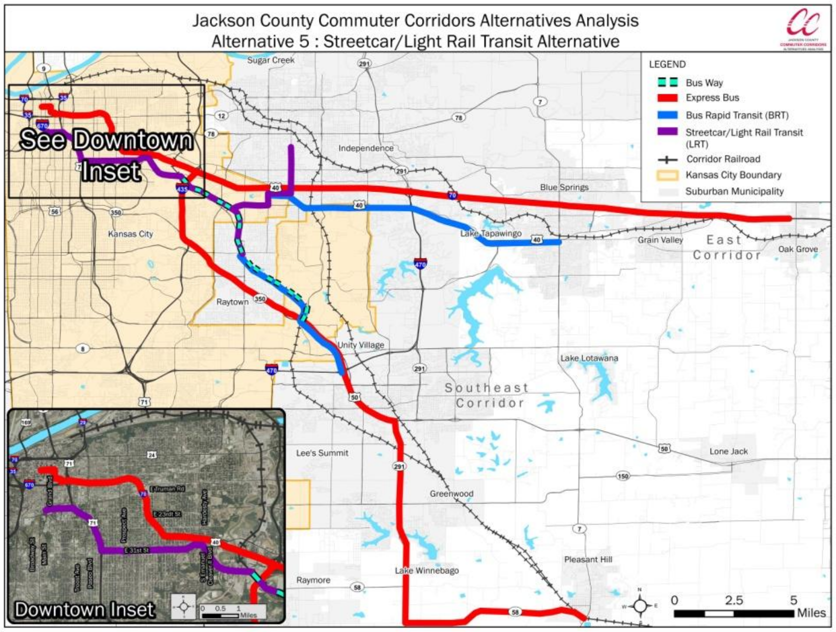



**Figure 4: LRT/Streetcar Alignments**

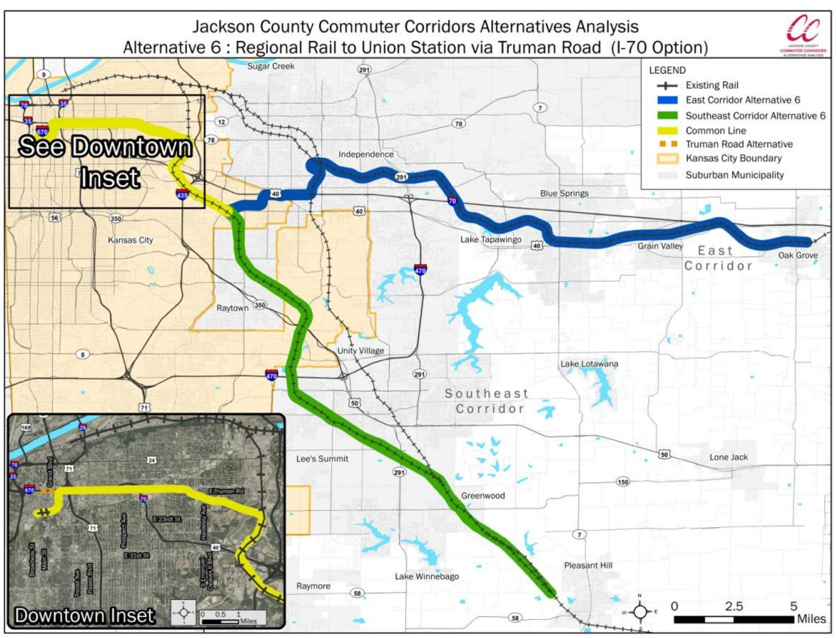



Figure 5: Regional Rail A Alignment

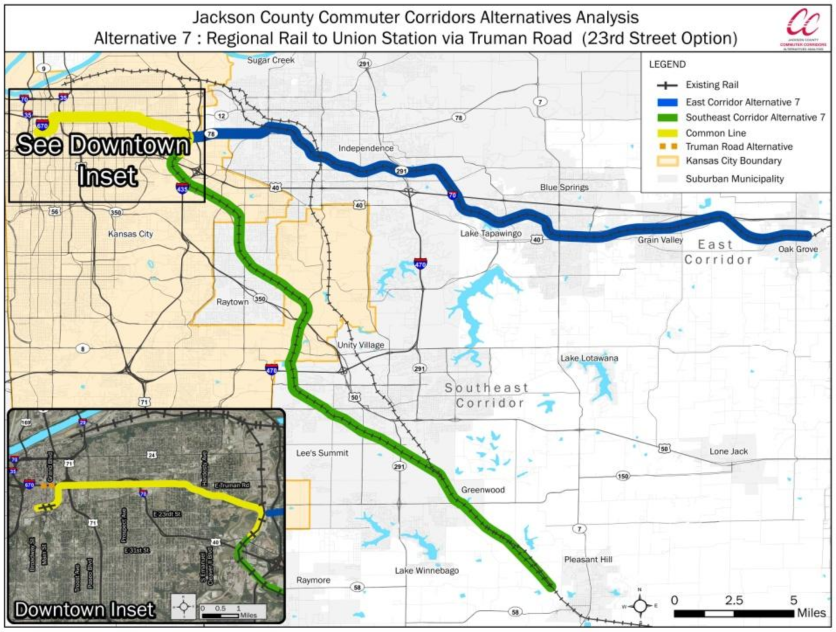



**Figure 6: Regional Rail B Alignment**

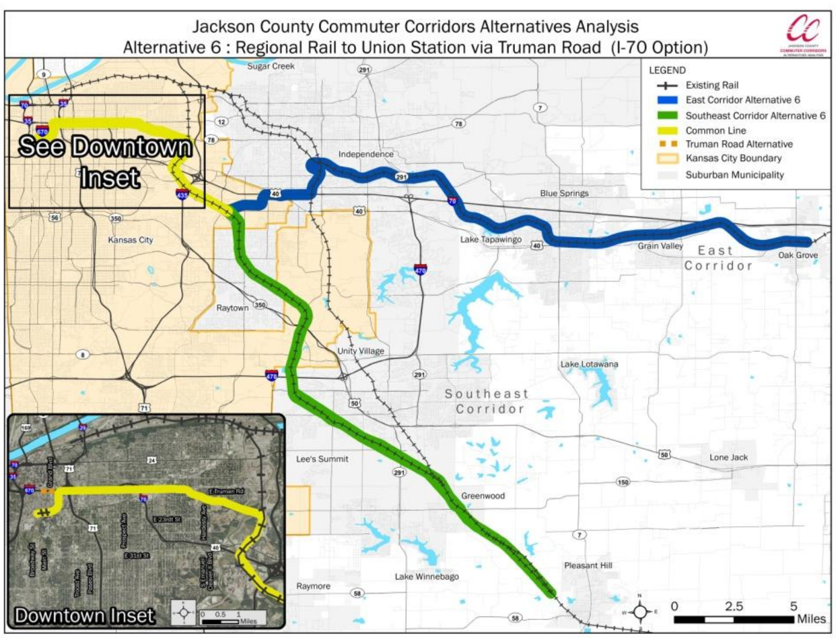



**Figure 7: Regional Rail C Alignment**

### II.4 Travel Markets

The key travel markets for this corridor are:

1. Work trips to the various areas of the CBD, both from suburban and urban residential areas.
2. Reverse-commute work trips to suburban business districts in the corridor
3. Special events trips to the Truman Sports complex (KC Royals, KC Chiefs and other concerts and events held at those stadiums).
4. Special Markets to CBD attractions, including the Sprint Center and other downtown sporting events (e.g., college basketball tournaments).

# III. KEY MODELING ISSUES

## III.1 Rail Demand Estimation

Since commuter rail or light rail service does not currently operate in the Kansas City modeled area, forecasting rail demand for a new regional rail system will inherently contain larger uncertainties than similar forecasts for other regions which have a history of urban rail use. To minimize this uncertainty, several modeling techniques can be used, including

- Run the AARF2 model to generate an independent estimate of overall regional rail demand. Though not intended to be a final estimate, the AARF2 model can be used to establish a general range of expected ridership, and is based on ridership data from other regional rail operations around the country.
- Consider including a distance-stratified transit constant. Currently the mode choice model uses a single transit constant calibrated to set the overall transit share. A distance-stratified constant will allow the model to be sensitive to the distance of a trip as a determining factor in transit share. Note that the transit constant is stratified by three income groups for home-based work trips.
- Review the model's ability to reflect current park-and-ride transit access demand. Currently park and ride demand is a small share of overall transit. However, regional rail demand is anticipated to include a large share of park and ride demand. A careful representation of park and ride access distances and times is also important in forecasting this access mode.
- Consider adjusting the headways to reflect greater reliability of rail operations. The mode choice model already stratifies wait time between short and long wait times, with a breakpoint at 7 minutes. However, if headways are greater than about 45 minutes, the modeled wait time may overestimate actual wait time of users.

## III.2 Treatment of Special Market trips

Special event/special market trips will be an important element in this corridor demand profile. The model does not consider special generators except for airport trips. College and university trips are treated as a separate trip purpose. The event-based trip generators (sports and entertainment activities) do not lend themselves to incorporation in a general travel demand model, which is intended to estimate trips for a typical weekday. However, information from each type of sporting or entertainment activity with regard to total attractions and distribution of attractions can be used to generate a separate trip table, which can be used as input to the mode choice model in a separate step. In this way, the special event demand can be treated in a consistent manner with regard to mode choice, but kept separate from the average day trips. The mode demand and associated user benefits can be annualized and added to the regular demand.

## III.3 CBD Access

Some of the alternatives, particularly regional rail, terminate at Union Station or other locations within the CBD. Figure 8 shows a preliminary alignment for rail access to the Union Station. No matter where the terminal CBD station is placed, access to other parts of the CBD is critical to accurately predicting ridership. When modeling this arrangement, special attention will be paid to:

- Access, egress and inter-modal transfer times between rail and bus, reflecting grade changes and any barriers to pedestrian transfer paths.
- Service frequencies and travel times for the shuttle/feeder service to and within the CBD. If a timed-transfer service is anticipated, the model will reflect shorter transfer wait times at this location. Figure 9 shows one potential circulator design that might be used to connect the CBD with the Union Station, while providing access and coverage to the CBD. Depending upon the particular alternative, the MAX service will also be considered as a possible link to the CBD.
- Careful, “faithful” coding of the circulation routes of the shuttle/feeder service at both the CBD and Crown Center/Union Station locations.

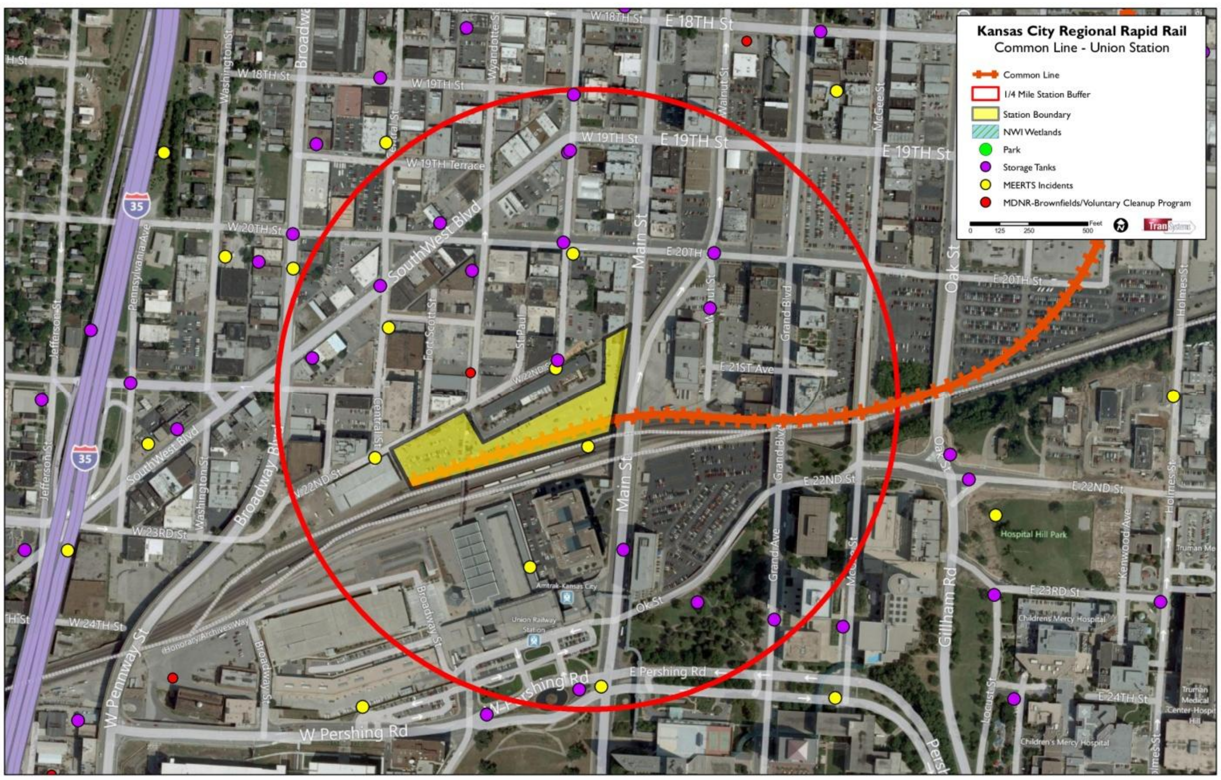



**Figure 8: Proposed Union Station Rail Configuration (TranSystems Corporation)**

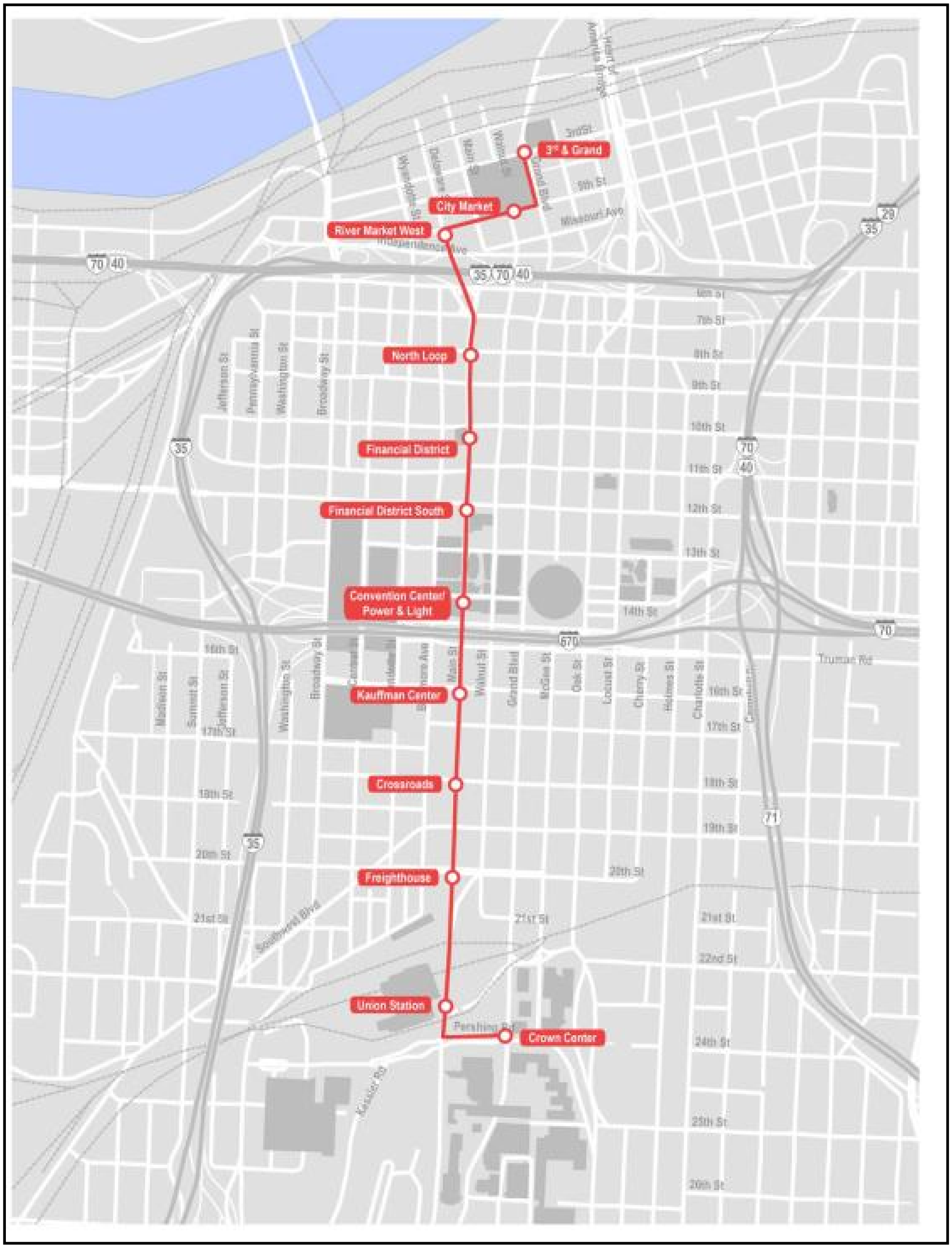



**Figure 9: Preliminary Downtown Circulator Alignment Candidate (Downtown Circulator Alternatives Analysis, Mid-America Regional Council, 2011)**

### III.4 BRT Representation and Demand

Several of the alternatives will use BRT as the primary mode or to extend coverage of another mode. The region does have an operating BRT – the Main and Troost MAX lines. A special on-board survey was conducted on the Main MAX route and this information is incorporated within the on-board survey data. Indications from tests by MARC show that the model-generated results for the Main MAX route were consistent with observed data by the modeling the MAX route as an express mode. While characteristics of the MAX riders are different from those of local bus riders, many of these are a result of service characteristics, such as a larger share of drive-access riders, and a greater orientation to the CBD. Higher rider demand was also modeled and observed, but this can be largely attributed to faster service. As a result of this experience, we anticipate keeping the mode choice mode structure, and representing BRT as an express mode.

## IV. MARC REGIONAL MODEL OVERIVEW

This chapter will give an overview of the MARC regional model. The MARC model was fully re-calibrated in 2007-2009 using the results of the 2005 home interview survey and 2005 Transit on-board survey. Figure 10 shows the overall model step sequence. The model includes a feedback routine involving distribution, mode choice and highway assignment. The feedback procedure continues until 99 percent of links between iterations have a travel time difference of less than 1 percent for both peak (am period) and off-peak (midday period).

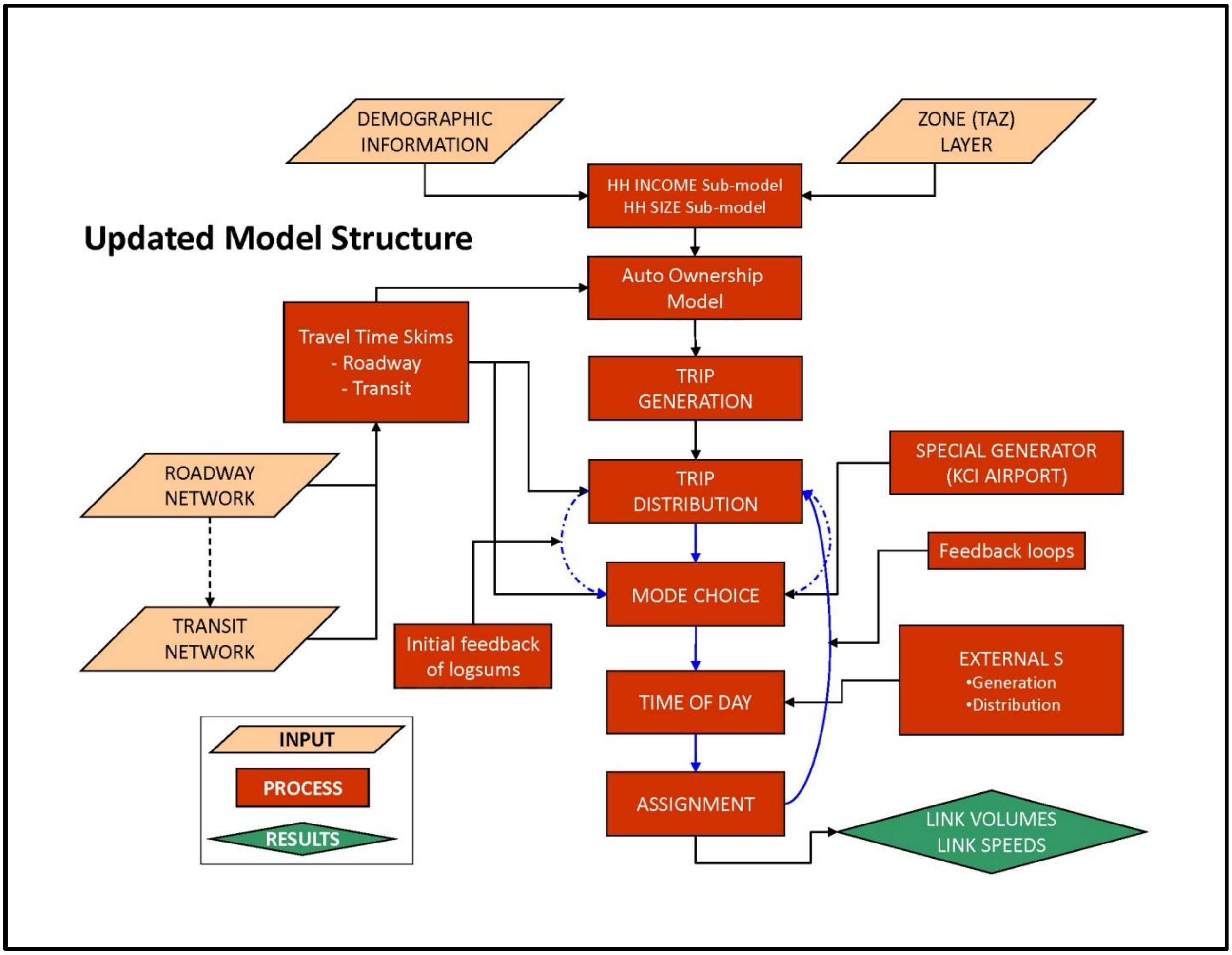



**Figure 10: MARC Model Flowchart**

The highway network was updated to include all freeway ramps, as well as horizontal alignment details. The zone system was expanded from the earlier 2005 version of the model and this expansion is shown in

Figure 11. This zone system was further expanded to include Johnson and Lafayette Counties within the study area, as shown in

Figure 12.

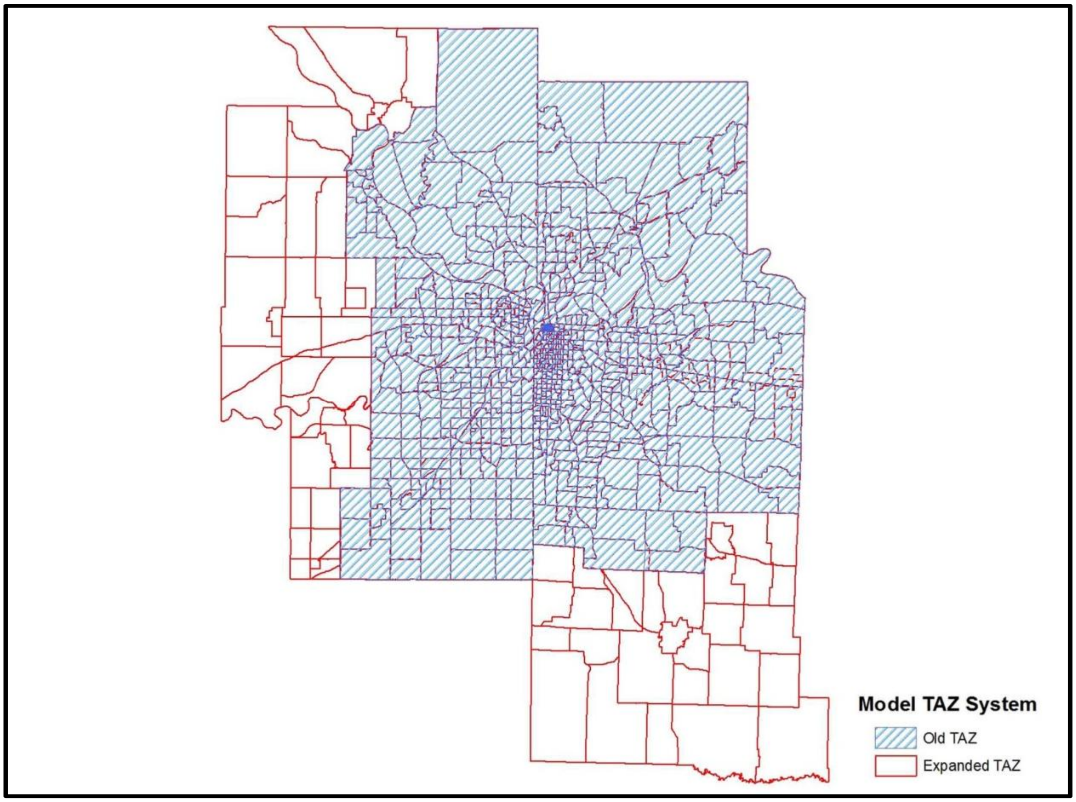



Figure 11: MARC Regional Model TAZ System

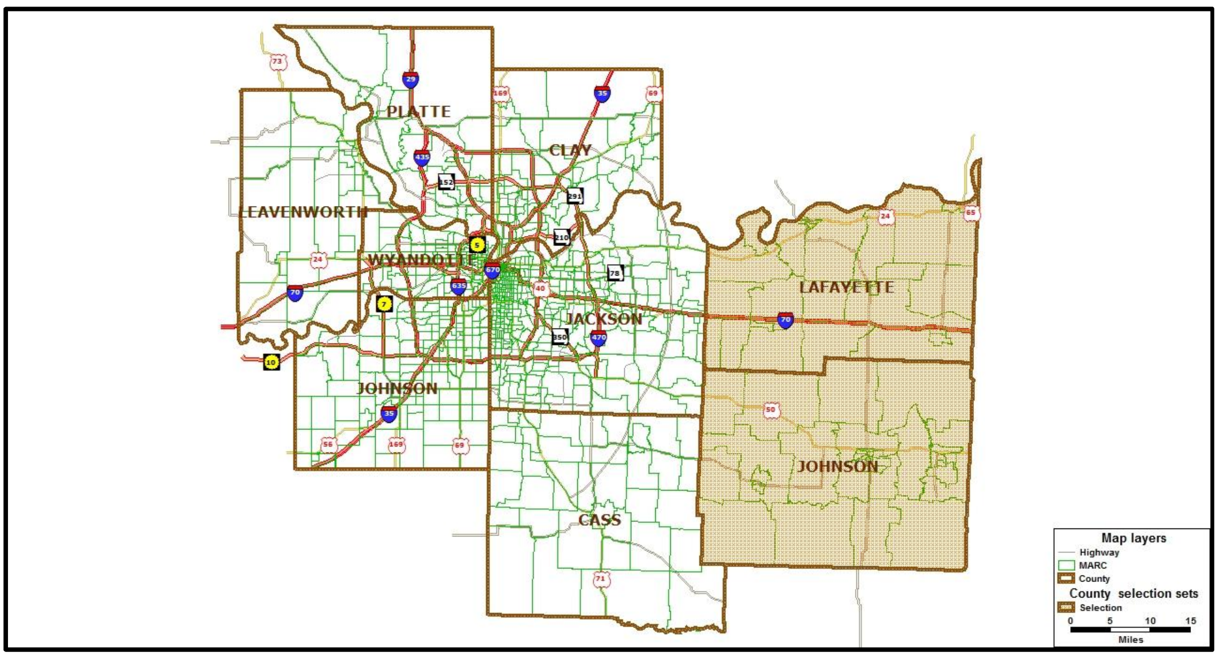



**Figure 12: Expansion of Zone System for JCCCA Study**

### IV.1 TRIP GENERATION

The trip generation program uses a cross-classification scheme for trip production, using household size and auto ownership as the independent variables. In addition, home-based work trips are stratified by three income classes. Sub-models are provided to prepare the inputs to the cross classification model. These include:

Household Income, using average zone household income to determine households by income (low, medium and high). Figure 13 shows the household income marginal distribution curves,

Household size, using average zone household size to determine households by sizes from 1 to 5+.

Figure 14 shows the household size marginal distribution curves, and

Auto ownership, which uses a logit model to estimate the probability of owning 0, 1, 2 or 3+ autos. Primary inputs are density and transit accessibility, with stratifications by household size and income.

The trip attraction model uses a linear regression equation to estimate trip attractions by zone. Home-based Work trip attractions are stratified into low, medium and high income categories based on distributions that vary by area type.

Trip attraction equations are specified as follows:

Trip Attraction Equations
**HBW** = 0.871*TE
**HBSHOP** = 1.6359*RET + 0.1861*OTH + 0.9521*HHLDS
**HBSR** = 0.7279*RET + 0.1978*OTH + 1.3533*HHLDS + 0.2869*SER
**HBO** = 0.1362*RET + 0.2889*HHLDS + 0.4377*SER
**NHBW** = 0.6114*RET + 0.3549*OTH + 0.3154*HHLDS + 0.4538*SER
**NHBO** = 0.9767*RET + 0.1990*OTH + 0.9472*HHLDS + 0.1479*SER

Where:
TE – Total Employment
RET – Retail Employment
SER – Service Employment
OTH – Other Employment
HHLDS – Total Households

The trip generation models and their sub-models were estimated using the 2005 home interview survey data and census transportation planning package (CTPP) data. The latter was used to estimate the marginal distribution curves for household size and income, due to their large sample size.

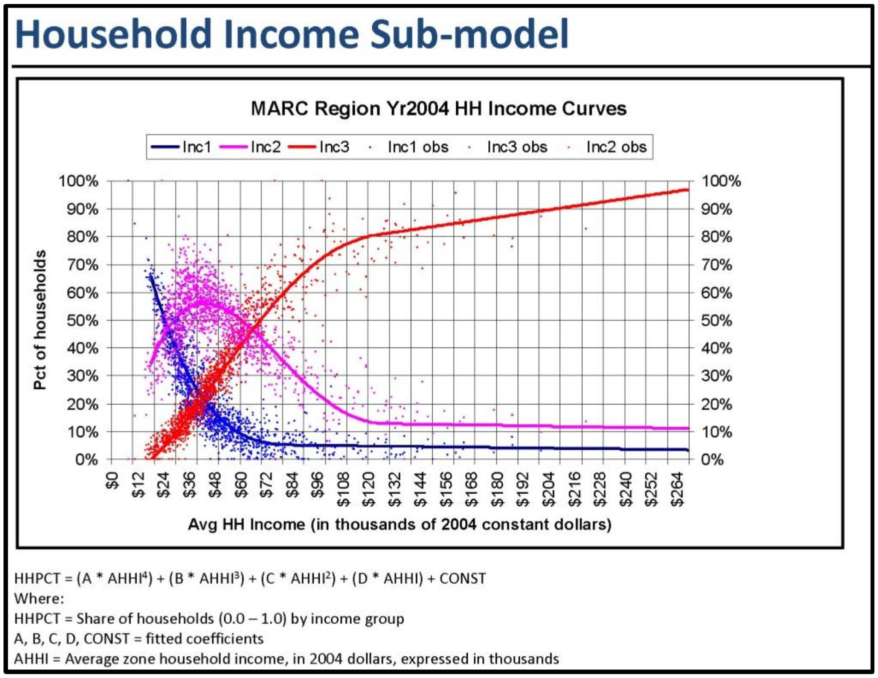



**Figure 13: Household Income Sub-Model**

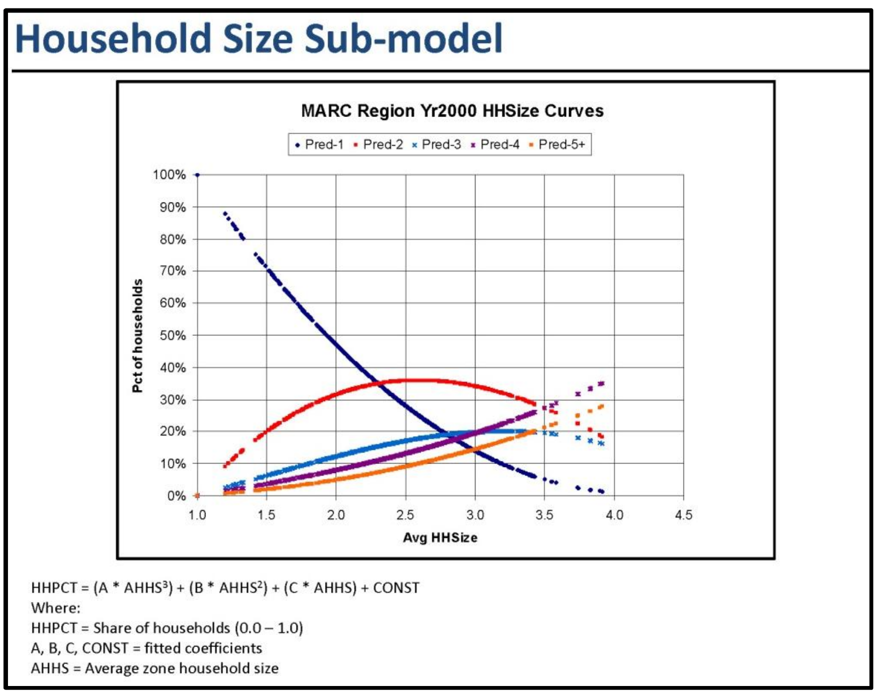



**Figure 14: Household Size Sub-Model**

## IV.2 Trip Distribution

The trip distribution model uses a destination-choice formulation, which uses the mode choice logsum total and distance as impedance for each trip purpose. Trip distribution is stratified by peak and off-peak periods. The model was estimated and calibrated based on the 2005 home interview survey. The HBW trip purpose is stratified by income as well. The same six trip purposes used in trip generation are maintained. In addition, airport trips are distributed without regard to distance, but proportional to households in the region, weighted by income.

### IV.3 Mode Choice

The mode choice model uses a nested logit choice formulation, stratified by peak and off-peak periods.

Figure 15 shows the nesting structure. Note that the model accommodates a rail mode, but this mode has not been calibrated, since there is no existing rail ridership data for the region. The model was estimated and calibrated using both the 2005 Home Interview Survey and the 2005 Transit On-board Survey.

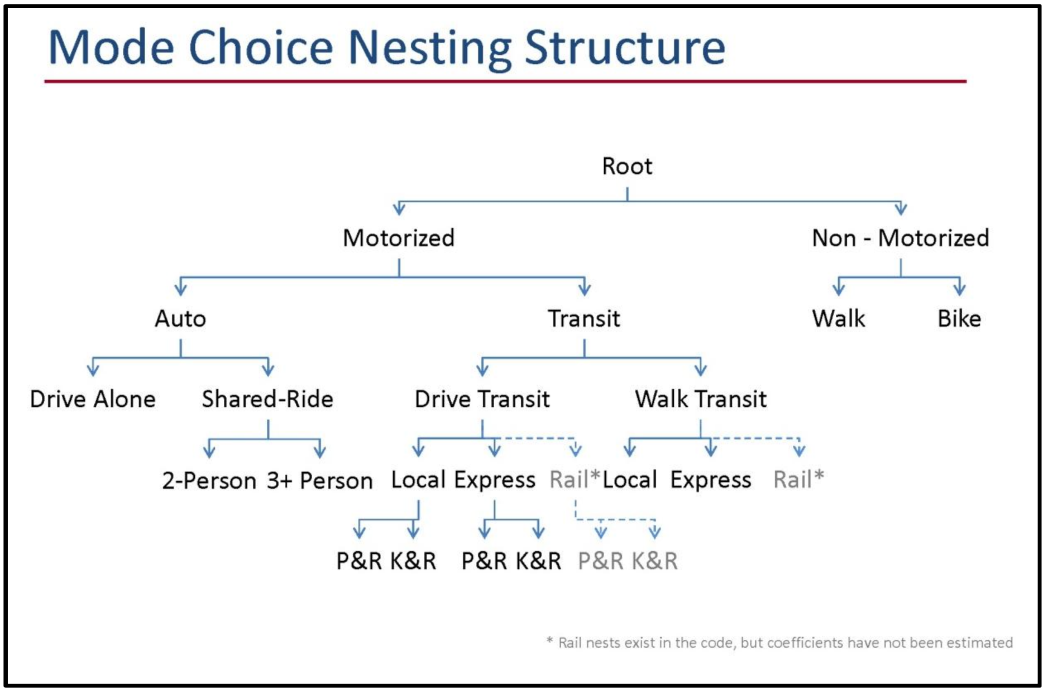



**Figure 15: MARC Mode Choice Nesting Structure**

### IV.4 Time of Day

After mode choice, hourly trip tables are created for auto trips, based on observed diurnal factors and directional factors. Figure 16 shows the diurnal and directional distribution for HBW trips. Separate factors are applied by trip purpose to generate auto trips. Transit trips remain in peak and off-peak, production to attraction format for assignment. Diurnal factors are based on the 2005 HIS.

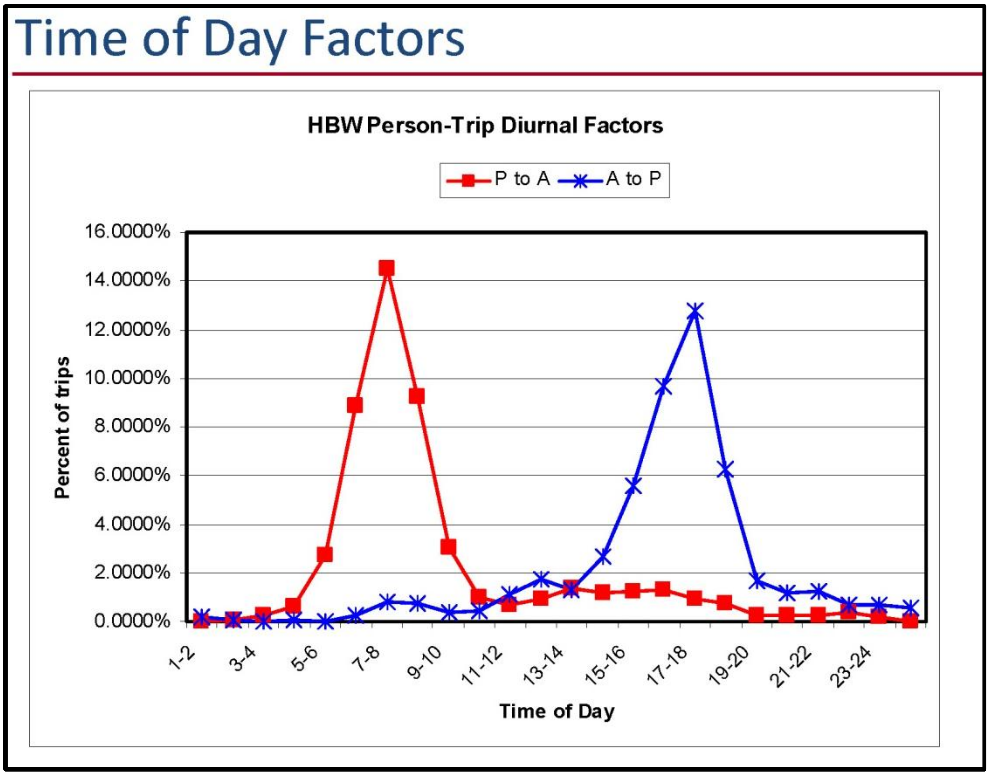



**Figure 16: Diurnal and Directional Distribution for HBW Person-Trips**

### IV.5 ASSIGNMENT

Hourly assignments are created using an equilibrium assignment algorithm embedded in the emme software. Transit assignments are executed using the optimum strategies algorithm embedded in the emme software. Transit travel time functions use a multiplier on highway speeds, stratified by facility type with a fixed dwell time per stop.

# V. INPUT DATA

## V.1 HIGHWAY NETWORKS

The Kansas City metropolitan area benefits from an expansive roadway network. This network serves both local and regional traffic. The main east-west Interstate through Kansas City is I-70, which bisects the heart of the Midwest and passes through the center of the study area. It is a limited-access freeway that connects the Kansas City metro area and other cities to the west to central Missouri, St. Louis, and other cities to the east. Between Odessa and the SR-7 interchange it is a 4-lane facility that widens to a 6-lane roadway west into downtown Kansas City. Currently, I-70 is being studied by MODOT in a second tier EIS to assess capacity and congestion issues. The first tier EIS analyzed a series of potential options to reduce congestion. Included in those options were transit solutions, including light rail and bus on shoulder. Currently, the identified solution to address congestion issues is to reconfigure key interchanges that cause bottlenecks in the system, and not to make additions to capacity (additional lanes). Due to shoulder width constraints, the current facility could not have a bus on shoulder operation; at this time, all transit vehicles operating on I-70 do so in mixed traffic. Figure 17 shows the regional highway system in the study area.

The following are other major highways that serve the study area:

- I-435 is a 6-lane circumferential Interstate highway that serves the outlying suburbs surrounding the Kansas City metro area.
- US-50 is a 4-lane highway going through the western and southern edges of Lee's Summit, MO to the cities in the east. It has limited access and grade-separated interchanges in Lee's Summit.
- US-40 is a 4-lane highway which parallels I-70 between Blue Springs and the I-435 and I-70 interchange. It has mostly at grade intersections but is a major east-west roadway. It goes through the northern part of the study area.
- SR-350 is a 4-lane major arterial connecting Lee's Summit to the urban core of Kansas City. It traverses directly through the study area corridor.
- SR-7 is a 2-lane highway connecting Pleasant Hill to US-50 and I-70 to the north.

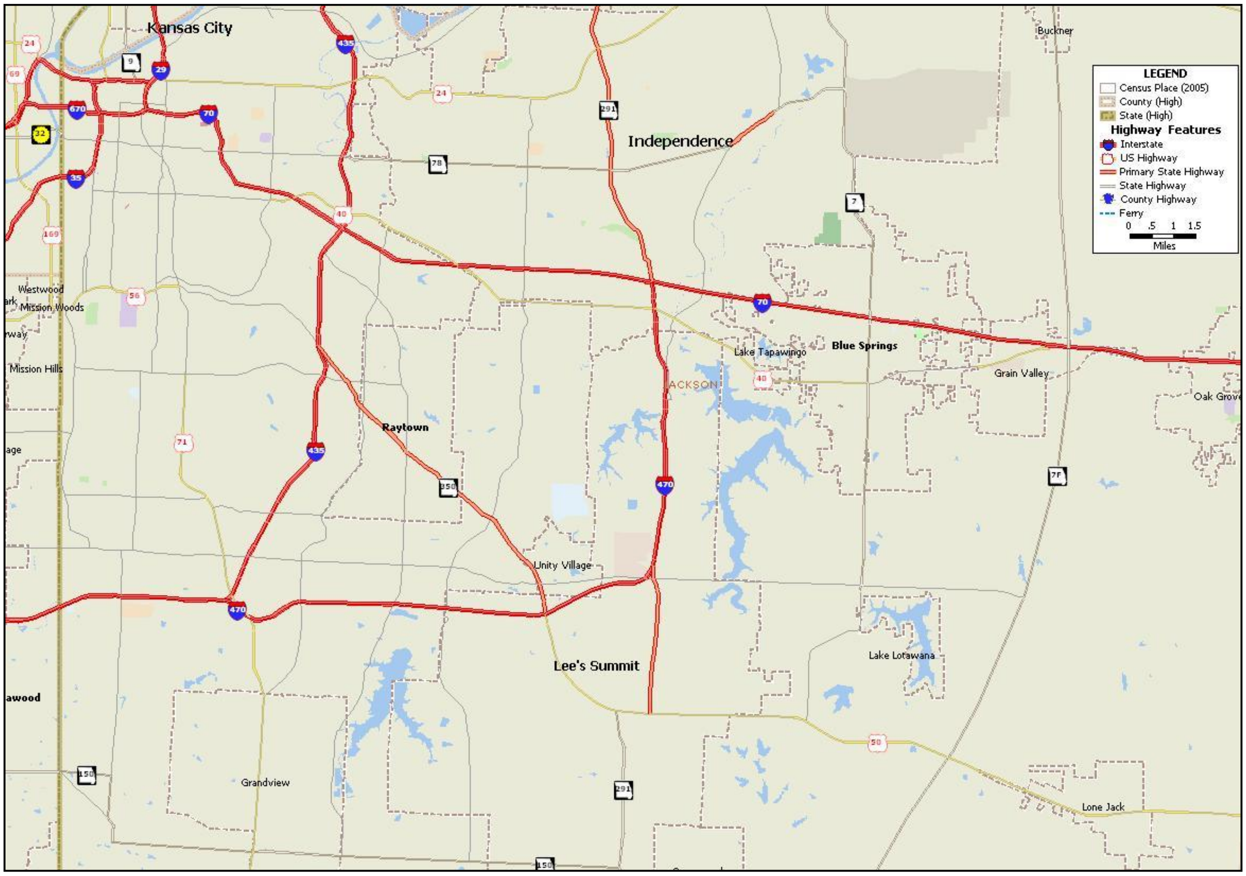



**Figure 17: Highway System in Study Area**

The highway networks will be based on the 2030 regional transportation plan by MARC, updated as necessary to reflect 2035 conditions. This includes all planned and programmed highway improvements. Within the corridor, there are no major highway improvements planned. In the extended model counties of Johnson and Lafayette, existing base map data was used to code the highway network.

## V.2 Transit Networks

A variety of transit services currently exist in the commuter corridor study area. This service includes eleven line haul routes: five KCATA routes and six City of Independence (operated by KCATA). These routes operate all day, with frequent stops along the route. The service also includes two MetroFlex routes (the Lee's Summit and Raytown Circulators) that provide call ahead, general public demand response services. The MetroFlex services have limited service hours and only operate within the city limits of the two cities. Additionally, there are commuter routes that serve Independence, Blue Springs and Lee's Summit. The KCATA is the primary public transportation provider within the study area,

The operating characteristics are described in Table 1 for each route that serves the study area.

**Table 1 - KCATA Operating Characteristics in the Study Area**

| Route Type | Route # | Route Name | Days/Week | Service Span | Peak Hour Frequency | Route Information |
|---|---|---|---|---|---|---|
| Line Haul | 24 | Independence | 7 | 4:43am - 6:48pm | 10-15 minutes | operates on Winner Road and Highway 24 |
| Commuter | 24x | Independence Express | 5 | 5:53am -7:41am and 4:09pm - 6:11pm | 2-30 minutes | operates on Truman Road |
| Line Haul | 28 | Blue Ridge | 7 | 4:25am - 11:12pm | 20 mimnutes | operates on Blue Ridge Blvd and US 40 |
| Commuter | 28x | Blue Ridge Express | 5 | 4:41am - 8:19am and 4:16pm-6:41pm | 20-30 minutes | operates on Blue Ridge Blvd and I-70 |
| Line Haul | 47 | Roanoke | 6 | 4:38am - 7:31pm | 17-40 minutes | operates on 47th Street and Southwest Trafficway |
| MetroFlex | 252 | Lee's Summit Circ | 5 | 7:30am - 5:30pm | demand response | operates within Lee's Summit city limits |
| MetroFlex | 253 | Raytown Circulator | 5 | 6:00am - 10:00am and 2:30pm - 6:30pm | demand response | operates within Raytown city limits |
| Commuter | 170 | Blue Springs | 5 | 5:42am-7:57am and 3:30pm-6:17pm | 5-30 minutes | operates on I-70 and highway 7 |
| Commuter | 152 | Lee's Summit | 5 | 5:15am - 7:56am and 3:37pm and 6:16pm | 30-40 minutes | operates on M-350 |
| Line Haul (Independence) | 183 | Green Independence | 6 | 7:36am - 5:54 pm | 60 minutes | operates on Noland Road, 23rd Street and I-470 |
| Line Haul (Independence) | 284 | Purple Independence | 6 | 5:31am - 5:57pm | 60 minutes | operates on Main Street and Noland Road |
| Line Haul (Independence) | 285 | Blue Independence | 6 | 5:35am - 5:55pm | 60 minutes | operates on Sterling Ave. |
| Line Haul (Independence) | 291 | Yellow Independence | 6 | 7:39am - 5:24am | 120 minutes | operates on Indepdenence Ave. |
| Line Haul (Independence) | 292 | Orange Independence | 6 | 7:32am - 5:55pm | 60 minutes | operates on Truman Road and Independence Ave. |
| Line Haul (Independence) | 293 | Red Independence | 6 | 8:01am - 4:57pm | 120 minutes | operates on Truman Road, Lee's Summit Road and 23rd Street |

The base 2035 transit network will represent the long range regional transit plan for 2030, updated to 2035 as necessary. No additional changes are anticipated from 2030 to 2035.

## V.3 SOCIOECONOMIC DATA

Socioeconomic data to support the forecast will be developed for the base year 2010 and forecast year 2035. The forecast year data will be based on regional growth assumptions by MARC. A 2030 forecast will be extended to 2035 to support the model horizon year. Data elements include population, households; retail, service and other employment, as well as average household income. All these elements are developed by traffic analysis zone. The transit access share, which is the percent of the zone within 1 mile of a transit stop, can be used to represent the effect of concentrated development around key transit stations. This will be applied uniformly for all alternatives. In the extended modeled zones in Johnson and Lafayette counties, this information was obtained from county forecasts and existing county databases.

# VI MODEL ADAPTATION

## VI.1 NETWORK EXPANSION

As shown in

Figure 12, the model coverage was extended to include Johnson and Lafayette Counties in Missouri. The zone system in these counties was based on census block-group definitions, so that census data could be more readily used in the model. Network was added to include all major freeways and arterials. Figure 18 shows the added zone system in Lafayette and Johnson Counties.

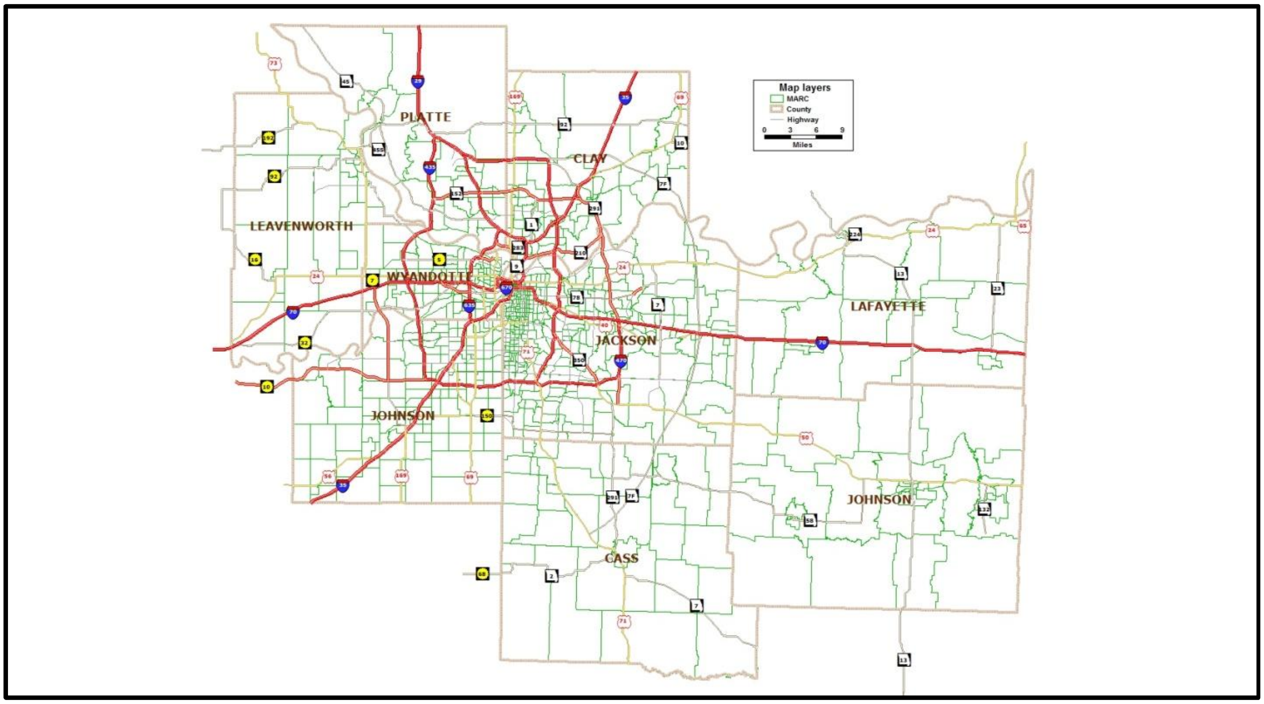



**Figure 18: Zone System Expansion**

## VI.2 NEW EXTERNAL TRIPS

With the network and zone expansion, new external stations were established on the external perimeter of Lafayette and Johnson Counties in Missouri. Counts were obtained from the Missouri DOT and new external station numbering was established. Former external stations that are no longer needed along the perimeter of Jackson and Cass counties were eliminated. Model procedures were updated to account for the additional external stations.

# VII VALIDATION DATA

The following data sources will be used for validation and where necessary, Calibration of the model.

## VII.1 YEAR 2000 CENSUS TRANSPORTATION PLANNING PACKAGE

This 1 in 6 sample was obtained from the US Census year 2000 "long form" and contains information on home and work locations of residents. The part 3 data contains worker flows. This data has been converted to zone to zone data flows for the modeled area. Further, worker flows were converted to daily person work trip flows by multiplying the worker flows by 1.454 which is the number of work half-tours per worker based on the 2005 home interview survey. This data is stratified by mode and income group. The CTPP data will be used to validate modeled work trip flows in the corridor.

## VII.2 LONGITUDINAL EMPLOYER-HOUSEHOLD DYNAMICS (LEHD), 2002-2009

This data will be used to adjust the CTPP worker flows and work trip flows to 2005 and 2010 conditions, Based on the relative growth in work productions and attractions by county from the LEHD data for 2002 to 2009. The LEHD data contains good historical growth trends at the county level, though government, military and self-employed workers are not included.

## VII.3 AMERICAN COMMUNITY SURVEY (ACS)

The ACS is a dataset of worker flows based on a rolling survey begun in 2005. Both 3 and 5 year totals are available at relatively large geographic scales. Worker flows can be obtained from the 3-year data. It offers and independent check on the growth assumptions obtained from the LEHD data.

## VII.4 2005 MARC HOME INTERVIEW SURVEY (HIS)

The 2005 HIS conducted for MARC provides a relatively small but robust sample of trip making in the region. However, it does not include household from Johnson and Lafayette Counties. It does, include a full range of non-work trip making. This dataset was used in the development, estimation and calibration of the current MARC regional model, Non-work trips modeled in this corridor may be compared to this database, excluding Johnson and Lafayette counties. It has been geocoded to the regional zone system for production and attraction trip locations.

## VII.5 2006 TRANSIT ON-BOARD SURVEY (OBS)

The 2006 transit on-board survey, conducted for MARC, included all transit operators in the region. In addition, supplemental transit on-board surveys were done to capture the characteristics of the Troost MAX route when it was implemented. A separate memo describes the applicability of this survey for use in this corridor, based on the relatively stable nature of the system since the 2006 OBS and in light of the supplemental MAX survey and its results. The transit on-board survey will be used to validate the transit path-building by assigning the transit on-board survey to the network. It will also be used to validate the mode choice transit totals within the corridor.

## VII.6 OBSERVED HIGHWAY SPEEDS

Peak and off-peak vehicle speeds on key highway segments will be used to compare with peak and off-peak speeds from the model assignment. These speeds are obtained from State DOT (KC Scout) and county sources.

## VII.7 OBSERVED TRANSIT SPEEDS AND LOADINGS

The Kansas City Area Transportation Authority (KCATA) has provided AVL and APC data for routes within the corridor. This information will be coded into the transit network, and compared with modeled speeds.

## VIII. CORRIDOR CALIBRATION AND VALIDATION PROCESS

The actual model validation will be focused on the study area corridor and how the model is representing travel in that corridor. Since the regional model has been recently calibrated, adjustment to the corridor should avoid fundamental model changes unless absolutely necessary. Adjustments to the model based on corridor travel behavior will typically be limited to and justified on the basis of corridor-specific behavior such as specific transit route travel times, or known trip generation or distribution characteristics. A model validation report will summarize the findings and model adjustments made to validate the corridor forecast for 2010. Any model adjustments arising from the calibration and validation process for 2010 will be implemented for all the 2035 forecast year model runs consistently.

### VIII.1 NETWORKS

Highway network speeds, especially congested speeds (AM peak hour) should show reasonable travel times, especially to the CBD. Maps of isochrones will be prepared from all zones to the CBD, focusing on our corridor area and showing that for peak hours the overall travel time is reasonable. We will also look for extreme outliers – where speeds are very slow in the peak hours – say less than 50% of the free-flow speeds – map these and investigate the reasons why this discrepancy occurs. The main objective is to identify any extreme values, such 10 mph on freeways, which might point to errors in coding (number of lanes?) and would lead to unreasonable bus speeds.

The transit network validation is of even more importance, though it is tied to the hwy speeds through the transit time functions. We want to show that, at least for the routes in the corridor, we have a good travel time representation, compared with 2005 observed travel times. If they are too far off, we will modify the transit travel time functions or line or stop-specific dwell times. In order to accomplish this comparison in a comprehensive way, we will code the observed travel times (peak/off peak, avg, min, max) into the transit segments as additional attributes – using the emme network calculator to move these down to links (probably in terms of transit speeds), and setting the transit time functions equal the observed times – this will allow comparisons with observed and estimated travel times, all through the model skim and path building processes. Transit travel time functions, using observed and estimated transit times compared with modeled highway speeds will also be done. Finally observed and estimated IVT skims and be generated and plotted to select destinations (i.e. to the CBD) for a good demonstration that not only the transit segment times, but the resulting skims are reasonable – the latter is important since that's what the mode choice model will actually use.

As a way of testing the validity of the path-building parameters, we will assign the transit on-board survey and look for:

- Unassigned trips – indicating network disconnections or survey geocoding errors
- Mode use mismatch – does the model assign the trip to a local bus when the stated mode is express
- Transfer ratio comparison between observed and estimated – may reveal transfer penalties that are too high or low.

Finally, the on-board survey will be used to evaluate the proper length of auto access connectors, based on observed auto access time and distance. This will be particularly important when coding drive access to stations in the regional rail alternatives.

### VIII.2 TRIP GENERATION

Modeled productions and attractions will be compared with observed data, including the CTPP expanded trips to 2010. Attractions to the CBD and Crown Center will also be compared.

Work-trip attractions to the CBD and Crown Center will also be checked for reasonableness for both 2010 and 2035. The ACS can also be used as an independent check on work trips.

### VIII.3 Trip Distribution

Corridor work trip distributions to the CBD and Crown Center will be compared with observed data from the HIS, CTPP and ACS data. This includes trip length frequency distributions, and district-to-district work trip flows. Low, middle and high-income stratifications of work trips will also be compared for reasonableness in distribution length and district-based distribution patterns. If necessary, K-factors may be introduced to achieve a more reasonable comparison, but destination-choice coefficients will be changed only if this can be justified by demonstrating unique characteristics of the corridor travel population.

### VIII.4 Mode Choice

The mode choice results will be examined against observed transit ridership in the corridor. Mode share by income and trip purpose, CBD orientation and access mode will be compared with observed data. Regional rail, light rail and streetcar mode-specific constants will be tested at both 0 and 6-16 minutes of equivalent bus in-vehicle time, depending upon the mode. Characteristics of the proposed regional rail, light rail and streetcar service will inform the use of a non-zero un-included attribute constant for these modes.

Comparison of transit mode share by distance will also be conducted. Currently, the model does not have distance stratification in its transit constant. If observed data suggests that distance stratification would improve the model's forecasts, this can be implemented in the mode choice code.

Adjustments will not include utility coefficients unless absolutely necessary and are justified based on unique characteristics of the corridor. Mode choice mode adjustments, if necessary, are more likely to include adjusted constants or new stratifications to existing constants.

# IX FORECAST PROCESS

This chapter describes the modeling steps that will be executed to produce the model forecasts.

## IX.1 BASE YEAR 2010

The base year 2010 forecast will be the product of the calibration/validation process described in the previous chapter. The model will be run through all steps, and a feedback check will be made to ensure that the LOS skims output from the highway assignment are consistent with the input skims to trip distribution and mode choice.

## IX.2 2035 NO-BUILD

Using the same model parameters and model execution procedures, a 2035 no-build model forecast will be prepared. The 2035 highway and transit networks, 2035 external volumes and 2035 socioeconomic data will be used as an input. As with the 2010 model run, the model will utilize a feedback procedure to ensure consistency with input and output level of service matrices. The same feedback closure criteria will be used for 2010 and 2035 model forecast runs. Transit model equilibration will be conducted if necessary to balance transit capacity with demand. This will be done by adjusting service headways.

## IX.3 2035 BUILD ALTERNATIVES

The 2035 Build alternatives, including the TSM/Baseline and mode-based build alternatives will be forecast using the same person-trip tables (by purpose) that were used on the final feedback iteration for the 2035 No-Build alternative to ensure that user benefits are not influenced by model-generated shifts in trip distribution. Transit mode equilibration will be conducted, as necessary, for these alternatives to ensure that the model represents sufficient transit capacity in relation to the demand.

## IX. 4 MODEL RESULTS

The forecasts will produce the following types of demand results:

1. Person-trips by mode and purpose for the region and corridor origin and destinations,
2. Transit line and link loadings, including peak link/peak hour loadings that can be used to estimate the fleet size,
3. Boardings and alightings for corridor routes, and a station-to-station demand matrix,
4. Specialized trip summaries to Crown Center and the CBD,
5. User benefits, summarized by production or attraction zone, by purpose. Other specialized summaries may be developed, such as user benefit by source of benefit, or by new or old user.

JACKSON COUNTY
COMMUTER CORRIDORS
ALTERNATIVES ANALYSIS

U.S. 71
Transit Study

# Model Validation Report (Draft)

November, 2012

MARC
Mid-America Regional Council

KCATA
Kansas City Area Transportation Authority

## Contents



# Intro

This document describes the development and validation efforts used on the Base Year (2005) MARC model used in support of the Jackson County Commuter Corridors Alternatives Analysis (JCCCAA) and US 71 AA projects. It describes the methods used to develop an additional base year using MARC 2010 data to include a BRT mode. The projects' purposes are to improve transit system performance and usage, addressing the identified transportation needs in three study corridors, to the east and southeast (JCCC AA), and south (US 71 AA) respectively of the Kansas City central business district.

## Overview of Model Updates/Changes

A brief overview of changes made to the MARC model as a part of the update process is below:

1. Network updates: I-35/I-435 interchange ramps fixed, US-71 ramps fixed. Johnson and Lafayette Counties added into model network.
2. Zones: Johnson and Lafayette Counties zones added into model. External stations updated.
3. Transit Network: Transit lines within the study corridors were updated to reflect actual routings, travel times, and headways.
4. Trip Generation: Adjusted trip attraction rates to the CBD, Crown Center, and Plaza/UMKC districts.
5. Trip Distribution: K-factors added in the study area corridors.
6. Transit Modes: Added BRT and CRT modes.
7. Skims: Split short and long walk markets. Split skimming process to account for local, express, BRT, LRT, and CRT modes. Added .01 spread factor for non-local transit modes. Updated access

connector links for P&R stations based on modes served. Updated transit path skim parameters based on linked versus unlinked trips from the On-board survey.

8. Mode Choice: Re-calibration of constants for 2010 with BRT mode included. Distance stratification for transit constants (not currently used). Nesting structure updated. BRT and CRT modes added. Model mode specific constants brought into FTA/Best practices ranges. Home-based other, home-based school, and home-based college trips were no longer aggregated for input. Recomputed transfer penalties and weighting Introduced an auto ownership function, which adds a piecewise-linear function to households with 0-auto ownership below a user-specified input.
9. Time of Day: Modified peak and off-peak transit trip tables used to generate skims in feedback iterations. Adjusted the AM peak period skimming definitions to better align with observed Inrix data for 2010
10. Highway Assignment: Modify closure criteria to 100 iterations, .01 best relative gap, and .01 normalized gap.
11. Transit Assignment: Assignment split by transit mode. Inclusion of spread factor (.01)

# Model Inputs

The first task was a review of the model inputs.

## Socioeconomic Data

Two sets of data were used in the modeling effort. The 2005 Socioeconomic dataset was taken from the MARC adopted 2005 land use data as well as 2000 census block data adjusted to 2005 county totals for coverage of Lafayette and Johnson Counties. Zone boundaries were established based on network density and census block boundaries. Employment data for the new counties was from 2000 CTPP data, scaled to 2005 totals. External station inputs were adjusted based on the new coverage as well. MoDOT traffic counts were collected at each station to determine the volume inputs at these stations. Figure 1 shows the 2005 population density by square mile for each TAZ in the modeled area.

Figure 1 – Population Density (Johnson and Lafayette Zones outlined in black)

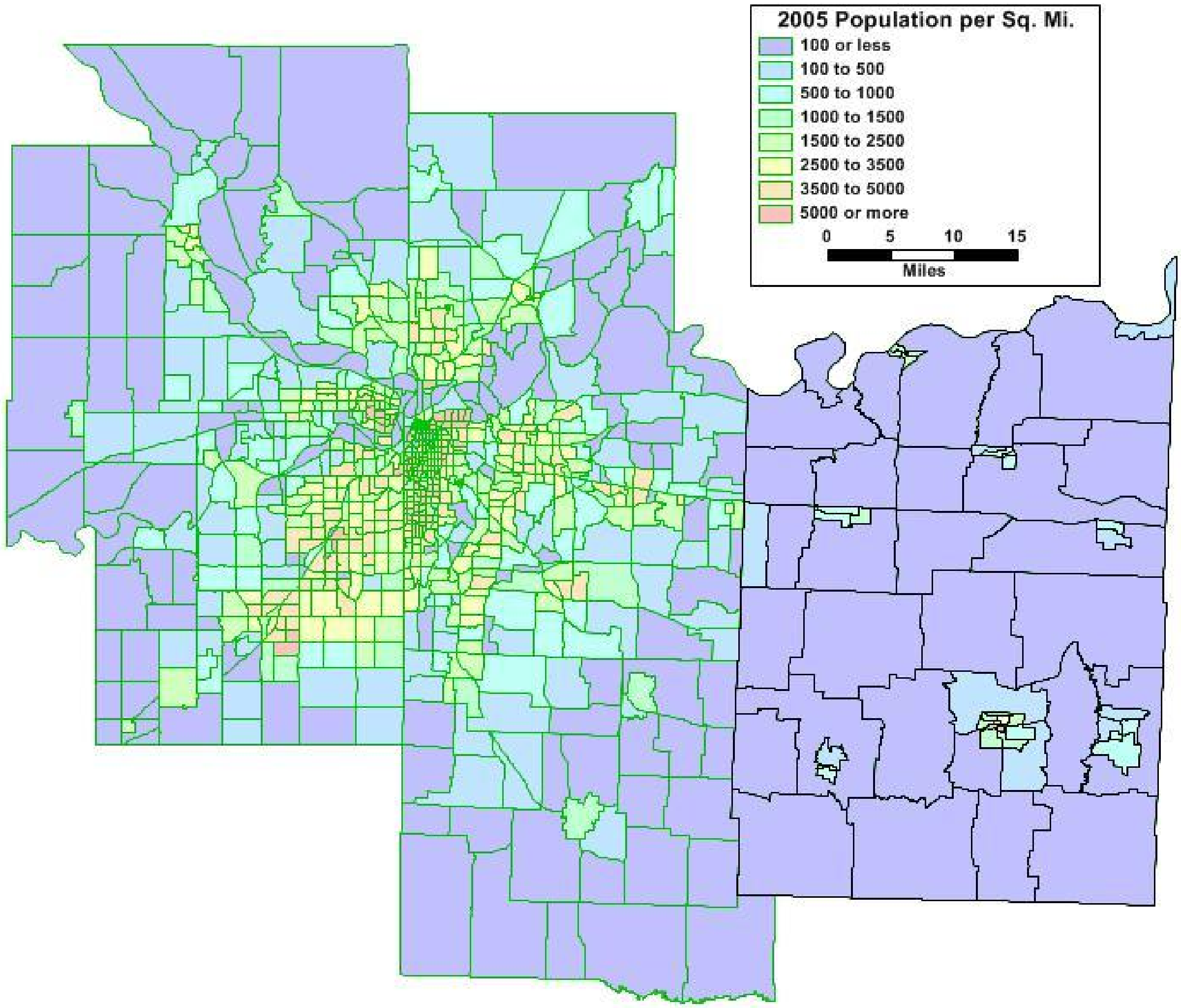
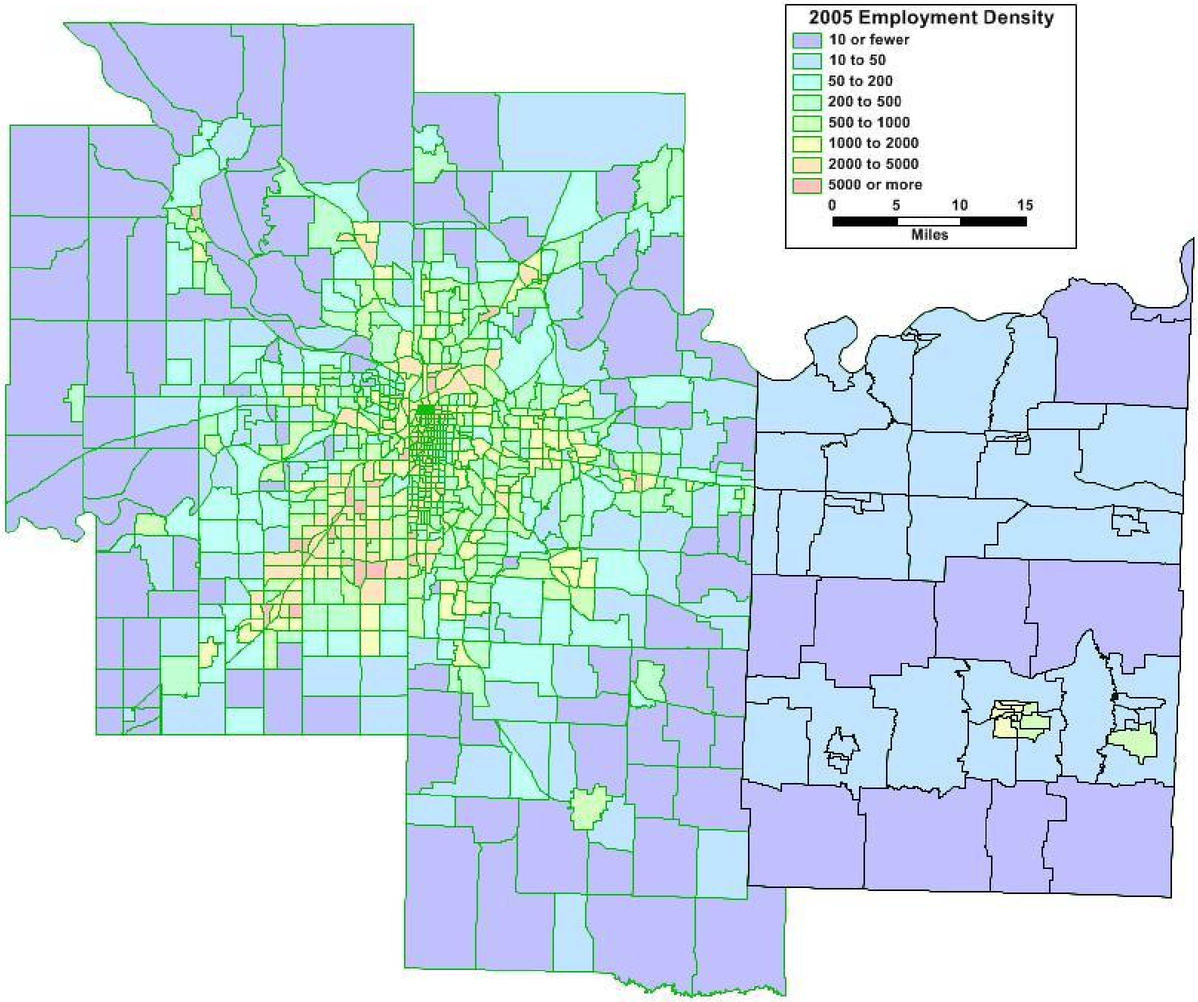



Figure 2 shows 2005 employment density in the modeled area.

Figure 2 – Employment Density (Johnson and Lafayette Zones outlined in black)




Socioeconomic inputs have been developed and reviewed by MARC staff, so no adjustments were made. In the new modeled areas, the census data was the best available data, so it was used. Data looked consistent to other modeled areas of similar land use type (rural) in terms of population and employment densities as well as overall county totals.

## Highway Networks

The base year (2005) highway network was developed by MARC staff as a part of the 2040 Long Range Plan process. The number of lanes and facility types in the study area were reviewed for errors. The base year networks were expanded by the Jackson County Commuter Corridors team to cover Lafayette and Johnson Counties to the east. The roadways selected for modeling in Lafayette and Johnson Counties included freeway and arterial facilities and reflected the coded network density typical of suburban/rural counties in the rest of the MARC model network. GIS street layer files were used as a basis for this new network area, and were reviewed using Google aerial photography. Figure 3 and Figure 4 show the regional network by lanes and Facility types.

Figure 3 - Expanded MARC Network by Number of Lanes

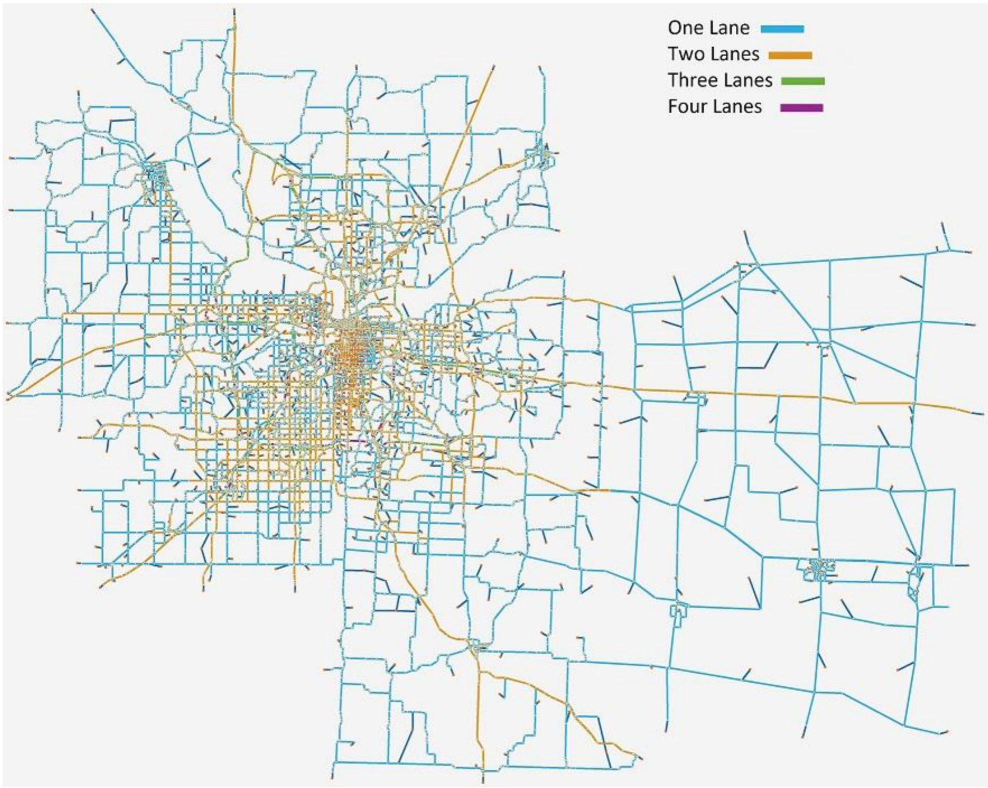
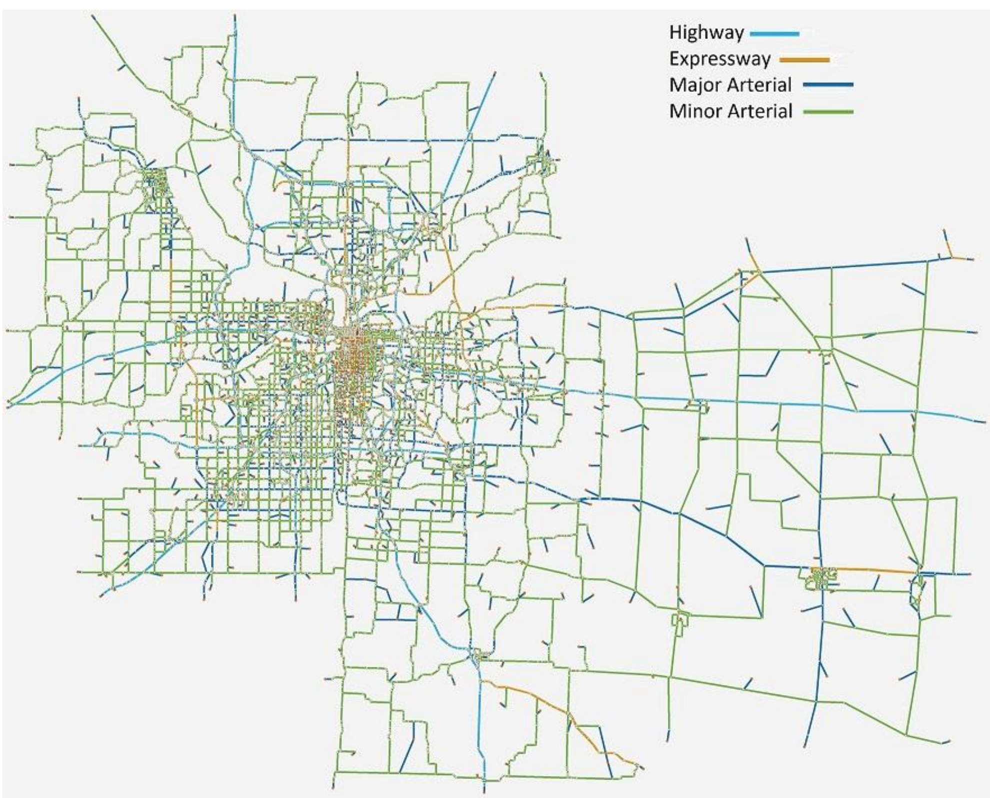
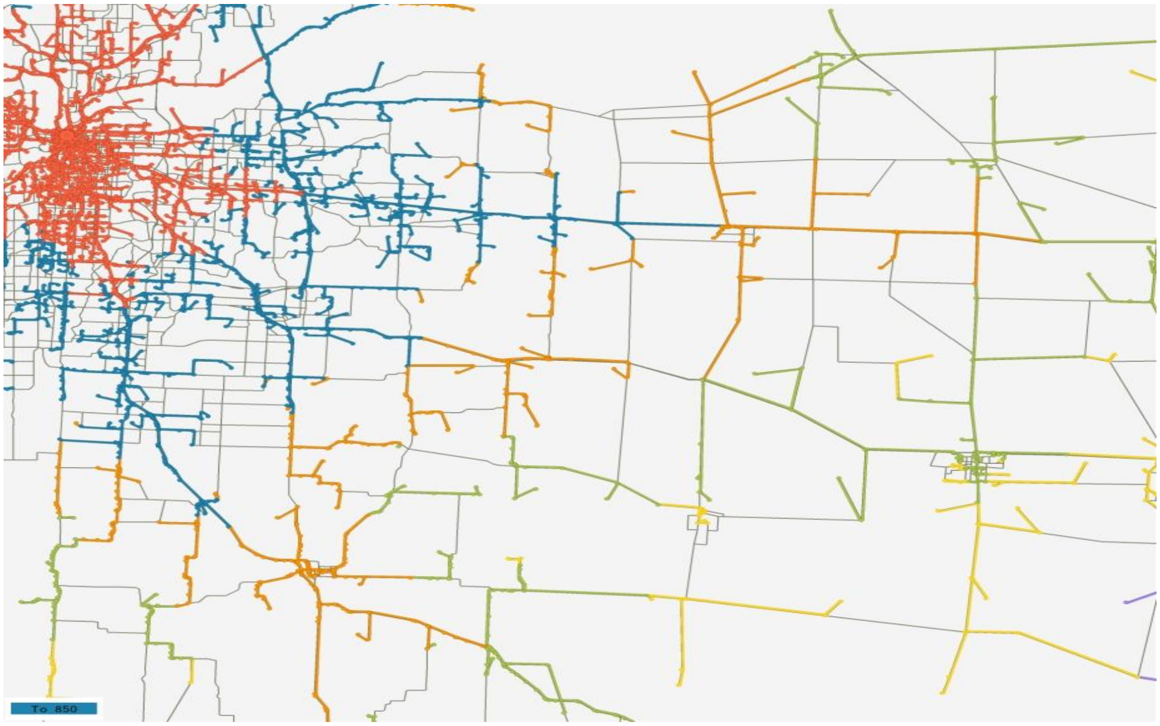



Figure 4 – Expanded MARC Network by Facility Type



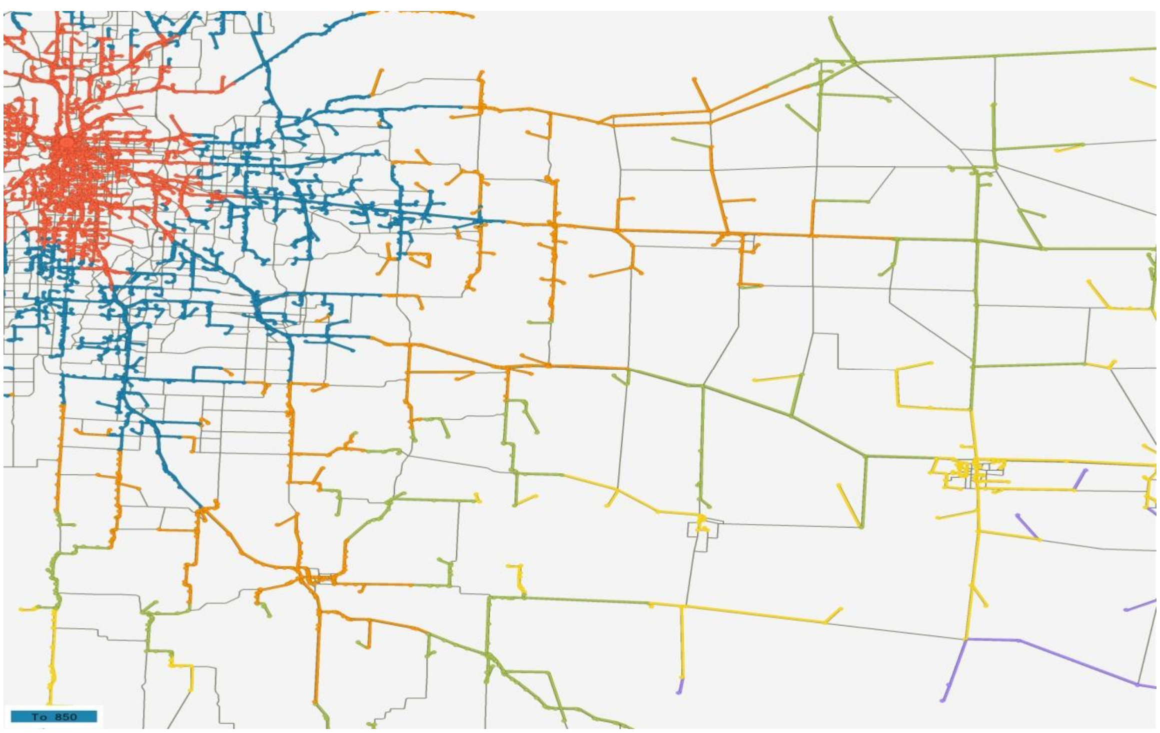
Travel times to a central CBD TAZ from any other TAZ in the off peak and AM peak hours are shown in Figure 5 and Figure 6. Each color represents a 15 minute time period. Travel time plots such as this were reviewed for reasonableness and to check for any coding errors within the network.

Figure 5 - Off Peak Travel Time in Study Area




The peak hour shows congestion, making the trip to the CBD longer for zones in the study area.

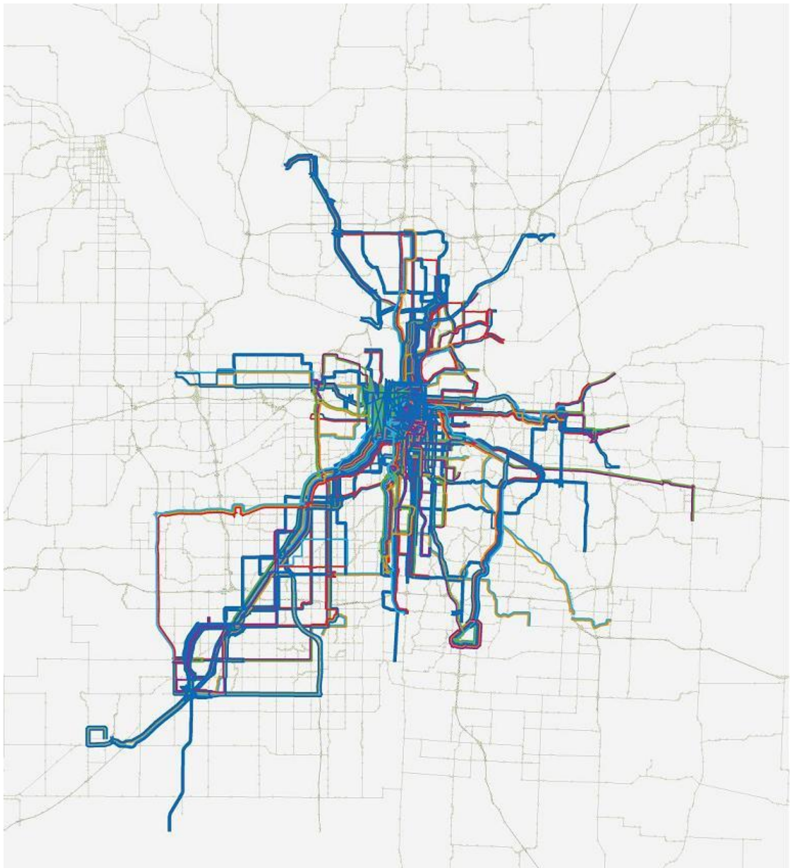
Figure 6 - AM Peak Hour Travel Time in Study Area



## Transit Networks

The 2005 transit lines in the corridors were reviewed for routing, speed, and headway accuracy. Some adjustments were made to the route beginning and termini to better reflect existing conditions. The 2010 transit network was created by updating the 2005 network to reflect changes in the system in the interim years. The 2005 transit network included local and express bus routes, while the 2010 transit network added the MAX BRT line.

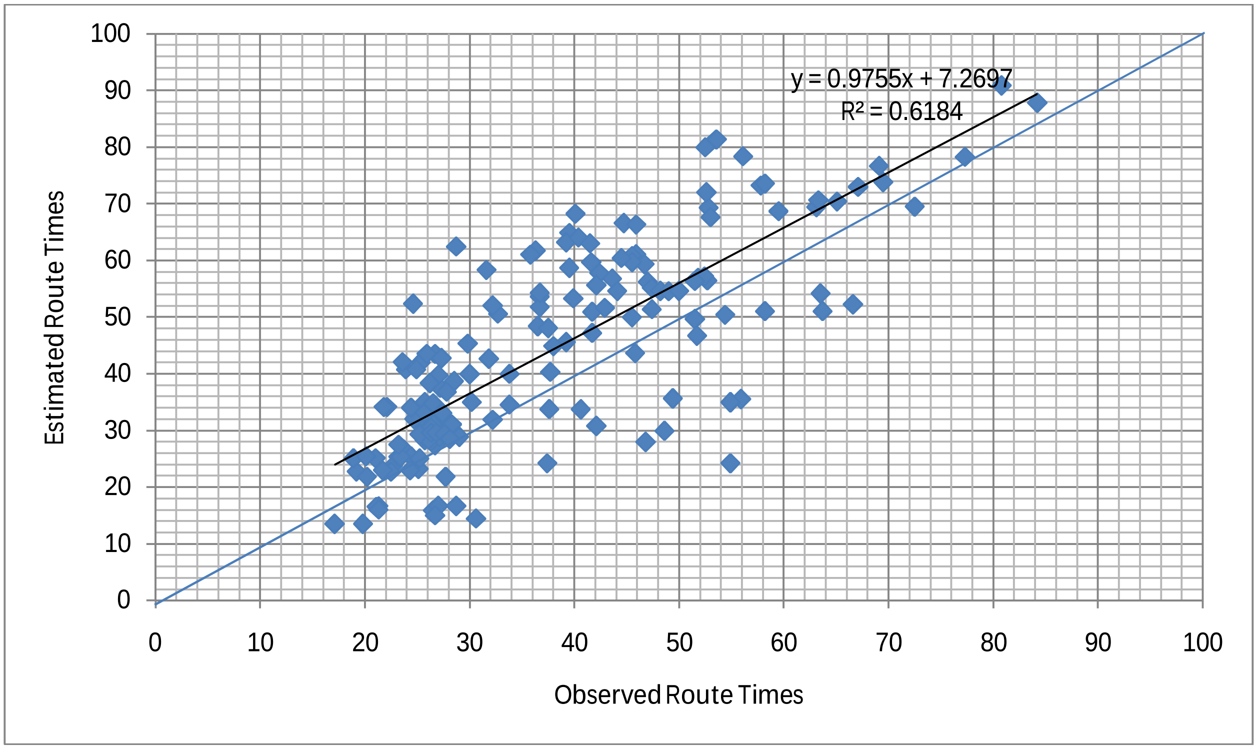
Figure 7 - MARC Model Transit Network



In order to evaluate transit loadings and speeds, observed transit data from the augmented 2005 MARC on-board survey as well as existing AVL data from the KCATA were considered. KCATA also provided some supplementary On-board survey data for selected routes, which was also reviewed. (The MARC On-board survey was augmented with the introduction of the MAX BRT system in 2008 by a survey of that line.)

Transit line speeds were evaluated by reviewing estimated modeled end-to-end running times against the observed AVL data. Headways were reviewed for the study corridor transit lines and were adjusted in some cases to better reflect actual conditions. In the study area, there were some routes that extend into rural areas that were significantly slower than observed end to end times. To speed up this service, a new transit travel time function was introduced. This was tested on several routes but was used only on route 47, which was an outlier compared to all routes. Figure 8 shows the comparison of end to end travel times for the peak hour transit lines in 2005 from the AVL data compared to the model.

Figure 8 - 2005 Peak Transit Travel Times




Transit travel times were also evaluated by time-point segment, as provided by the KCATA. This data was hard to use in the model, as the actual transit distances between segments was not included, and therefore made computation of observed speeds on the segments difficult. Despite the difficulties here, an initial comparison of the observed versus estimated speeds by facility type was performed. This yielded inconsistent results and was not used for the validation.

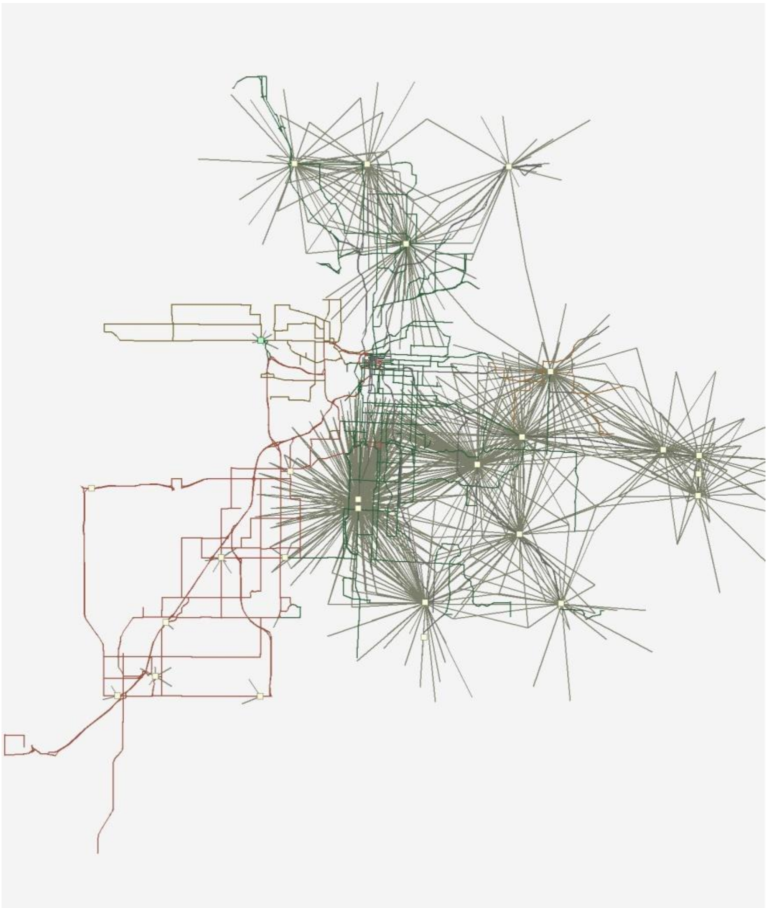
## Initial Assignment

Trip tables from the On-Board Survey were provided by MARC. These trip tables were assigned to the existing transit network. These trip tables were split into local and express trips based on further documentation provided by MARC.

Some on-board survey records were not assigned to the network because either the starting zone or destination zone did not have access to the transit network. These unassigned trips accounted for 2.5% of the total observed demand. After review of these trips, changes to the access conditions were not changed as these trips had very long paths that were determined to be unrealistic. These unassigned trips were primarily walk access trips.

The On-board survey suggests that the existing access conditions for walk and kiss-and-ride trips are sufficient. Park-and-ride access links were originally set to a minimum of 1 mile, however, the survey suggested that there were existing park-and-ride users coming from zones that were less than 1 mile away. Therefore, the minimum access condition was removed to allow users in closer zones to use park-and-rides. Figure 9 shows the peak Park and Ride links connecting them to transit lines.

Figure 9 - Peak Park & Ride Access Links



The Park and Ride access procedure was ultimately adjusted to create separate links on the Kansas side versus the Missouri side, as well as separate link generation for BRT lines.

## Study Area Evaluation Districts

The study area was split into several districts for further evaluation and refinement against observed data. These districts will be referred to throughout the remainder of this document. Figure 10 shows the district definitions used for the Jackson County Commuter Corridors Alternatives Analysis (JCCCAA) and US-71 Alternatives Analysis (US71AA).

Figure 10 – JCCCAA Study Area Model Districts

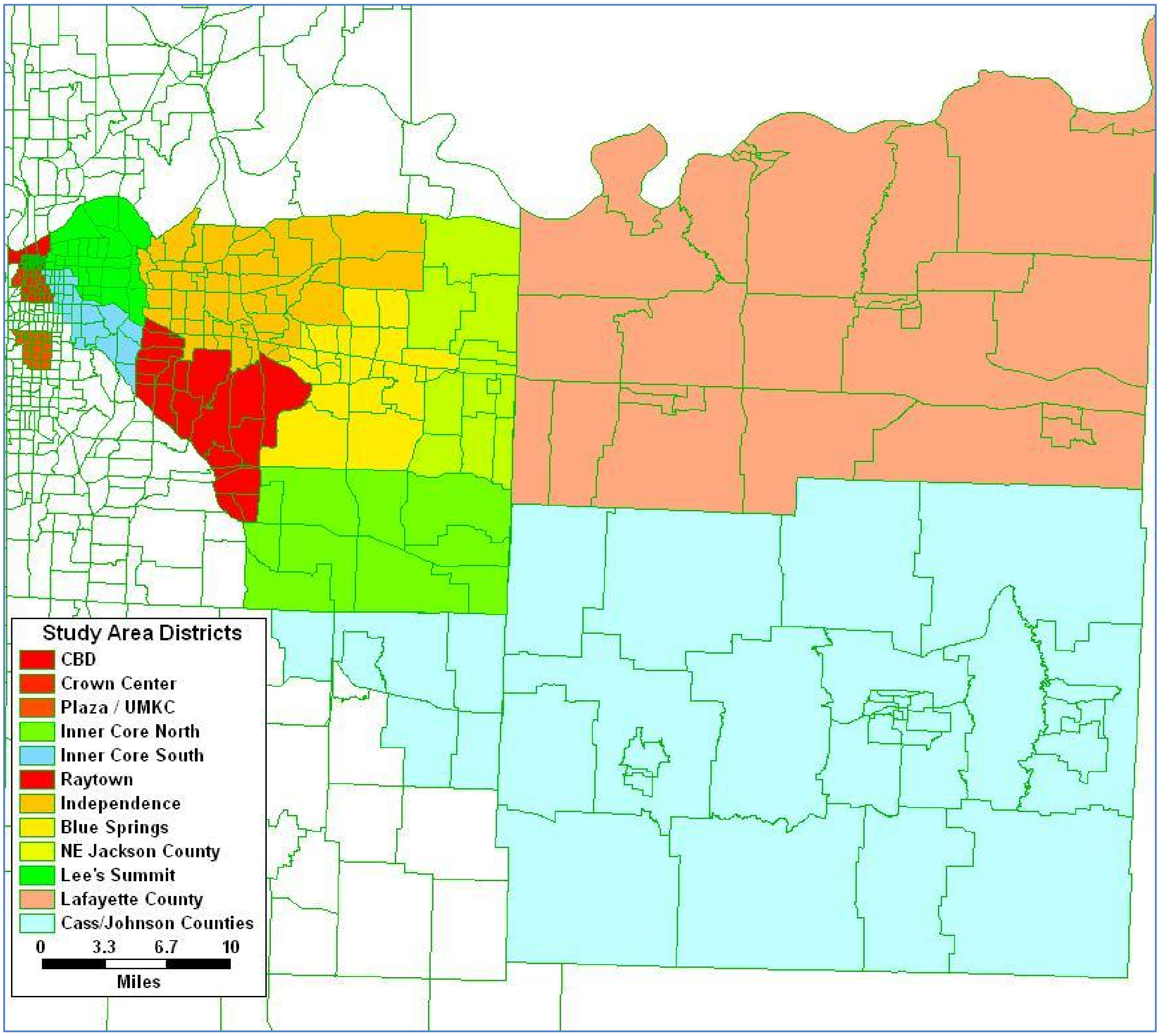
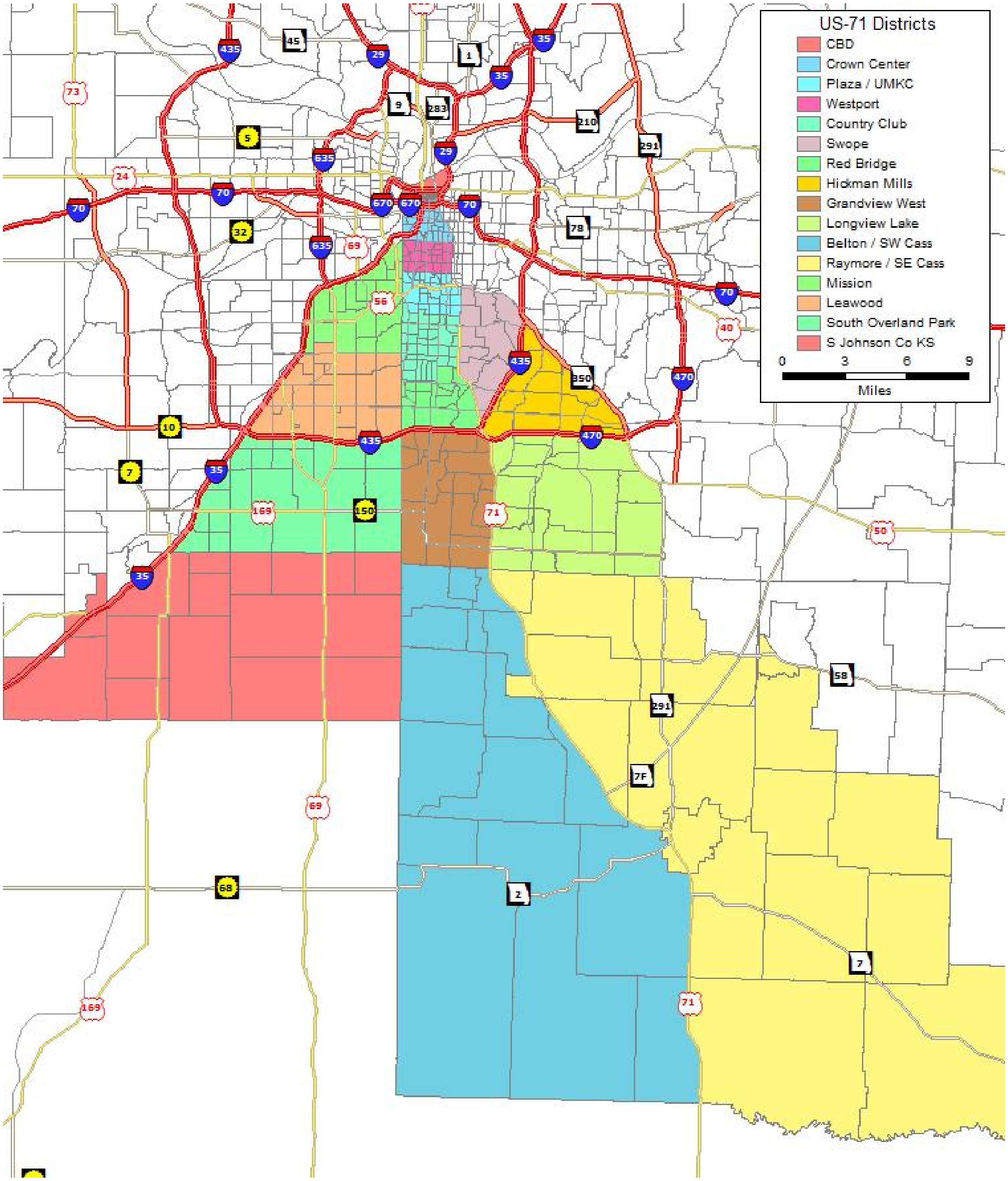



Figure 11 shows the districts that were added to for the US-71 Alternatives Analysis (US71AA). The definitions overlap in the CBD, Crown Center, and Plaza districts. It also added a Westport district.

Figure 11 - US71AA Study Area Model Districts



# Model Steps

## Trip Generation

The model validation made use of Census 2000 CTPP data, scaled to 2005 using LEHD-derived growth factors. Using data from the 2005 Home Interview Survey, the 2005 CTPP Worker flow matrix was multiplied by 1.454, which is the number of work half-tours per worker to produce a table of observed Home-Based Work trips from the CTPP worker flows. These figures were used for comparison with the modeled output.

In Table 1, the CTPP work tour totals are compared to Modeled HBW production and attraction totals. In addition, peak hour NHBW values were computed to round out the other trips that may have began at home and ended at work with an additional stop or stops.

Table 1 – Comparison of 2005 productions and attractions

| | Productions | Attractions |
|---|---|---|
| CTPP Work Tours | 1,307,000 | 1,307,000 |
| | | |
| Model TG HBW | 1,248,000 | 1,248,000 |
| Model TG Peak NHBW | 114,000 | 114,000 |
| Sum | 1,362,000 | 1,362,000 |

Table 2 shows the production totals by county from the model versus what is in the CTPP. Jackson County trip generation shows a very good comparison to the Census data.

Table 2 – Comparison of Home-Based Work Trip Productions by County

| | Trip Generation Model | CTPP Work Tours |
|---|---|---|
| Johnson KS | 322,000 | 407,000 |
| Leavenworth KS | 44,000 | 46,000 |
| Wyandotte KS | 100,000 | 100,000 |
| Cass MO | 64,000 | 61,000 |
| Clay MO | 153,000 | 144,000 |
| Jackson MO | 444,000 | 424,000 |
| Johnson MO | 36,000 | 44,000 |
| Lafayette MO | 24,000 | 21,000 |
| Platte MO | 61,000 | 60,000 |
| TOTAL | 1,248,000 | 1,307,000 |

Table 3 shows the attraction totals by county from the model versus what is in the CTPP. Note that the model scales Home-based work trips to the production totals, and those values are reflected here.

Table 3 – Comparison of Home-Based Work Trip Attractions by County

| | Trip Generation Model | CTPP Work Tours |
|---|---|---|
| Johnson KS | 408,000 | 383,000 |
| Leavenworth KS | 27,000 | 31,000 |
| Wyandotte KS | 94,000 | 107,000 |
| Cass MO | 30,000 | 35,000 |
| Clay MO | 114,000 | 120,000 |
| Jackson MO | 476,000 | 527,000 |
| Johnson MO | 28,000 | 33,000 |
| Lafayette MO | 13,000 | 14,000 |
| Platte MO | 58,000 | 57,000 |
| TOTAL | 1,248,000 | 1,307,000 |

Trip generation was looked at in detail for trip attractions in the CBD, Crown Center, and Plaza areas, which are the main work-trip attractors in the study area. Table 4 gives the production totals at these destinations in the study area.

Table 4 – Home-Based Work Productions in Study Area

| | Trip Generation Model | CTPP Work Tours |
|---|---|---|
| CBD | 3,700 | 3,900 |
| Crown Center | 12,900 | 15,500 |
| Plaza | 4,400 | 4,100 |

Trip Attraction rates specific to the key study area destinations; CBD, Plaza, and Crown Center, were reviewed against LEHD and CTPP observed attraction rates per employee. These observations led to an adjustment in trip rate for HBW attractions. The trip attraction rate in the model is 0.832*Employment for each zone. In the distribution step, HBW attractions are normalized to the HBW production control totals. Adjustments were applied to the attraction rates for the CBD, Plaza and Crown Center to better match the observed trip rates for these districts shown in Table 5.

Table 5 - Home-Based Work Trip Attraction Rates to Study Area Key Destinations

| District | Attraction Rate Adjustment Factor | Modeled Trip Attractions Per Employee | CTPP Trip Attractions Per Employee |
|---|---|---|---|
| CBD | 0.95 | 1.42 | 1.42 |
| Crown Center | 1.34 | 1.62 | 1.64 |
| Plaza | 0.81 | 1.38 | 1.34 |

Table 6 shows the attraction totals for the major work destinations in the study area prior to any adjustments. While the number of trips attracted to the CBD was close, further refinement was necessary based on income levels.

Table 6 – Home-Based Work Attractions in Study Area

| | Trip Generation Model | CTPP Work Tours |
|---|---|---|
| CBD | 69,200 | 72,700 |
| Crown Center | 37,900 | 36,100 |
| Plaza | 37,400 | 54,400 |

Table 7 compares the trip generation modeled attractions against the 2005 employment totals in the major work destinations for the study area.

Table 7 computes the number of attractions per employee.

Table 7 – Home-Based Work Attractions Per Employee

| | Model HBW TG Attrs | 2005 Total Employment | Model Work Attrs/Employee |
|---|---|---|---|
| CBD | 69,200 | 51,800 | 1.34 |
| Crown Center | 37,900 | 27,200 | 1.39 |
| Plaza | 37,400 | 33,600 | 1.11 |

## Distribution

Trip comparisons were made for both person trips and transit trips against observed data by trip type and by income level. HBW Trip distribution was compared to the CTPP distribution in several ways to assess the accuracy of the model with respect to income groups. Modeled transit trips were compared to observed trips from the MARC On-Board Survey. Table 8 shows the distribution of trips from districts in the study area and counties to the CBD by income group.

Table 8 - Home-Based Work Trip Relative Distribution Comparison to the CBD (As a percentage of the regional trips)

| FROM | TO | Model TOTAL | Low Income | Med Income | High Income | CTPP TOTAL | Low* Income | Med* Income | High Income |
|---|---|---|---|---|---|---|---|---|---|
| Outer N | CBD | 1% | 3% | 1% | 0% | 1% | 1% | 1% | 0% |
| Outer S | CBD | 0% | 0% | 1% | 0% | 1% | 1% | 1% | 1% |
| Independence | CBD | 11% | 15% | 12% | 7% | 6% | 7% | 7% | 5% |
| Blue Springs | CBD | 2% | 1% | 2% | 3% | 4% | 2% | 4% | 5% |
| Raytown | CBD | 3% | 2% | 3% | 4% | 4% | 2% | 4% | 5% |
| Jackson SE | CBD | 1% | 0% | 0% | 1% | 2% | 1% | 1% | 3% |
| Jackson NE | CBD | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 1% |
| Inner Core S | CBD | 4% | 8% | 5% | 1% | 3% | 7% | 3% | 1% |
| Inner Core N | CBD | 10% | 24% | 10% | 2% | 4% | 11% | 5% | 1% |
| Study Area | CBD | 33% | 54% | 34% | 19% | 25% | 32% | 26% | 21% |
| Jackson Co | CBD | 48.2% | 69.4% | 50.0% | 33.5% | 47.2% | 65.8% | 50.2% | 38.9% |
| Cass Co | CBD | 1.4% | 0.6% | 1.2% | 2.1% | 2.1% | 2.4% | 2.2% | 2.0% |
| Johnson MO Co | CBD | 0.3% | 0.3% | 0.5% | 0.1% | 0.6% | 0.9% | 0.6% | 0.5% |
| Lafayette Co | CBD | 0.9% | 2.9% | 0.6% | 0.1% | 0.6% | 0.5% | 0.7% | 0.5% |
| Region | CBD | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |

*split income group 15000-29999 matrix into 15000-25000, 25000-29000 by multiplying original into 2/3 and 1/3

Table 9 compares trips by county in the corridor to Jackson County.

Table 9 - Home-Based Work Trip Distribution Comparison to Jackson County (As a percentage of the regional trips)

| HBW Comparison FROM | TO | Model TOTAL | Low Income | Med Income | High Income | CTPP TOTAL | Low* Income | Med* Income | High Income |
|---|---|---|---|---|---|---|---|---|---|
| Cass Co | Jackson Co | 4.1% | 2.1% | 4.5% | 4.5% | 2.7% | 3.0% | 4.4% | 1.6% |
| Johnson MO Co | Jackson Co | 1.1% | 4.3% | 0.8% | 0.1% | 1.0% | 2.2% | 1.8% | 0.4% |
| Lafayette Co | Jackson Co | 2.0% | 8.1% | 1.2% | 0.2% | 0.8% | 1.1% | 1.5% | 0.4% |
| Region | Jackson Co | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |

*split income group 15000-29999 matrix into 15000-25000, 25000-29000 by multiplying original into 2/3 and 1/3

Trips were also examined by income group for select destinations. Adjustments based on area type and income group were made for the CBD to improve the distribution by income group to the CBD, shown in Table 10.

Table 10 - Home-Based Work Attraction Factors By Area Type

| Income Group | CBD | Fringe, Suburban, Rural | Urban |
|---|---|---|---|
| Low | 0.0435 | 0.0903 | 0.0698 |
| Medium | 0.3165 | 0.5362 | 0.4836 |
| High | 0.64 | 0.3735 | 0.4466 |

Table 11, Table 12, and Table 13 show the trip attractions by destination comparing Home-Based Work trip destinations to the CTPP.

Table 11 – Home-Based Work CBD Trip Attractions

| CBD | CTPP | | MODEL | |
|---|---|---|---|---|
| Inc1 | 5,433 | 7.5% | 6,967 | 9.6% |
| Inc2 | 31,945 | 44.0% | 31,751 | 43.7% |
| Inc3 | 35,298 | 48.6% | 33,858 | 46.7% |
| Total | 72,676 | | 72,576 | |

Table 12 – Home-Based Work Crown Center Trip Attractions

| Crown Center | CTPP | | MODEL | |
|---|---|---|---|---|
| Inc1 | 5,031 | 9.2% | 5,099 | 9.4% |
| Inc2 | 24,295 | 44.6% | 23,330 | 43.1% |
| Inc3 | 25,113 | 46.1% | 25,642 | 47.4% |
| Total | 54,438 | | 54,071 | |

Table 13 – Home-Based Work Plaza/UMKC Trip Attractions

| Plaza UMKC | CTPP | | MODEL | |
|---|---|---|---|---|
| Inc1 | 3,879 | 10.7% | 4,152 | 11.2% |
| Inc2 | 14,655 | 40.5% | 17,812 | 48.0% |
| Inc3 | 17,612 | 48.7% | 15,107 | 40.8% |
| Total | 36,146 | | 37,071 | |

Regional trip length frequency distributions were created to compare estimated person trip lengths against observed person trip lengths. In general, the modeled lengths looked consistent with the observed lengths.

The trip length distributions were considered based on varying levels of detail Figure 12 shows the relative trip length frequency distribution, by income group, for home-based work trips in the entire modeled area. Figure 13 shows the relative trip length frequency distribution, by income group, for home-based work trips from the study area corridor to the entire modeled region. Figure 14 shows the relative trip length frequency distribution, by income group, for home-based work trips from the study area corridor to the CBD.

Figure 12 – Home-Based Work Trip Length Frequency Distribution – Regional, by Income

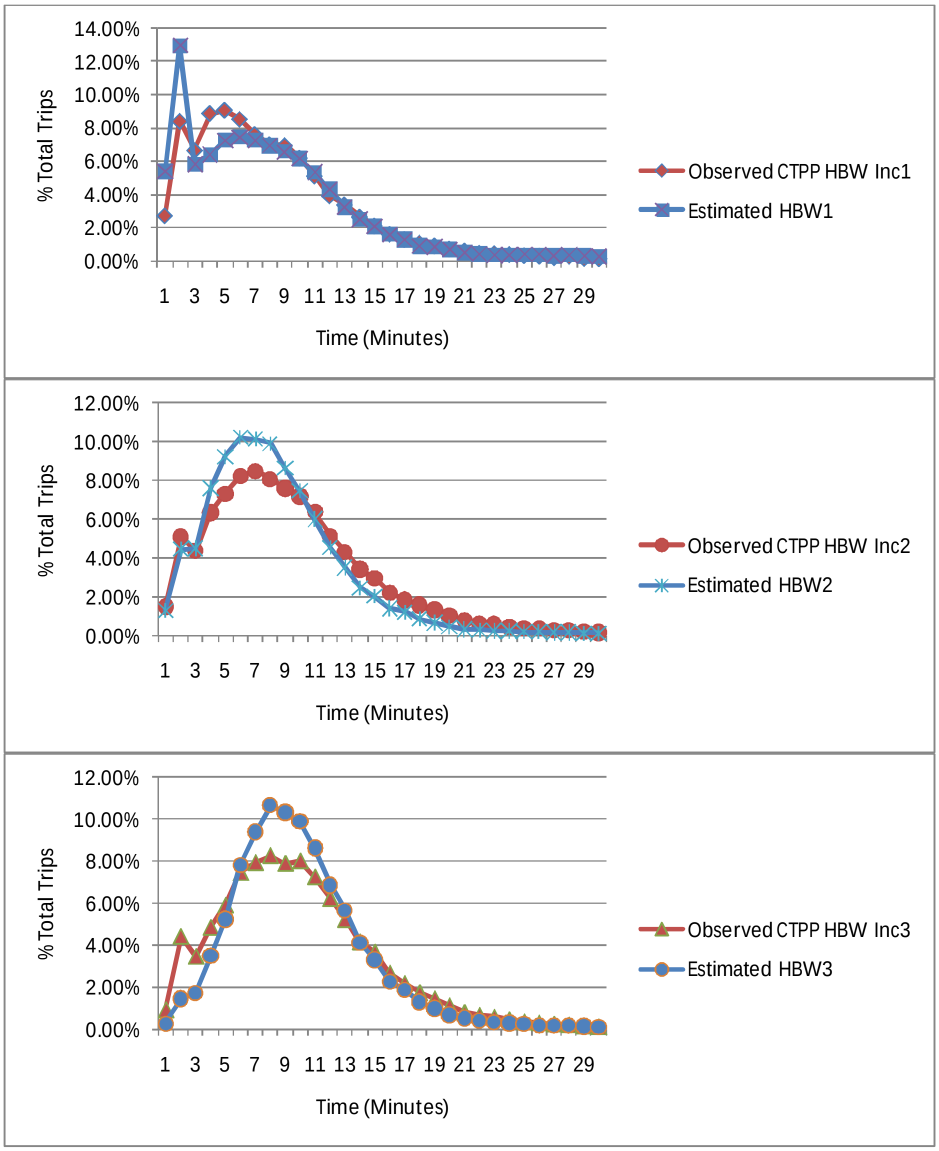


Figure 13 – Home-Based Work Trip Length Frequency Distribution - Corridor to Region, by income

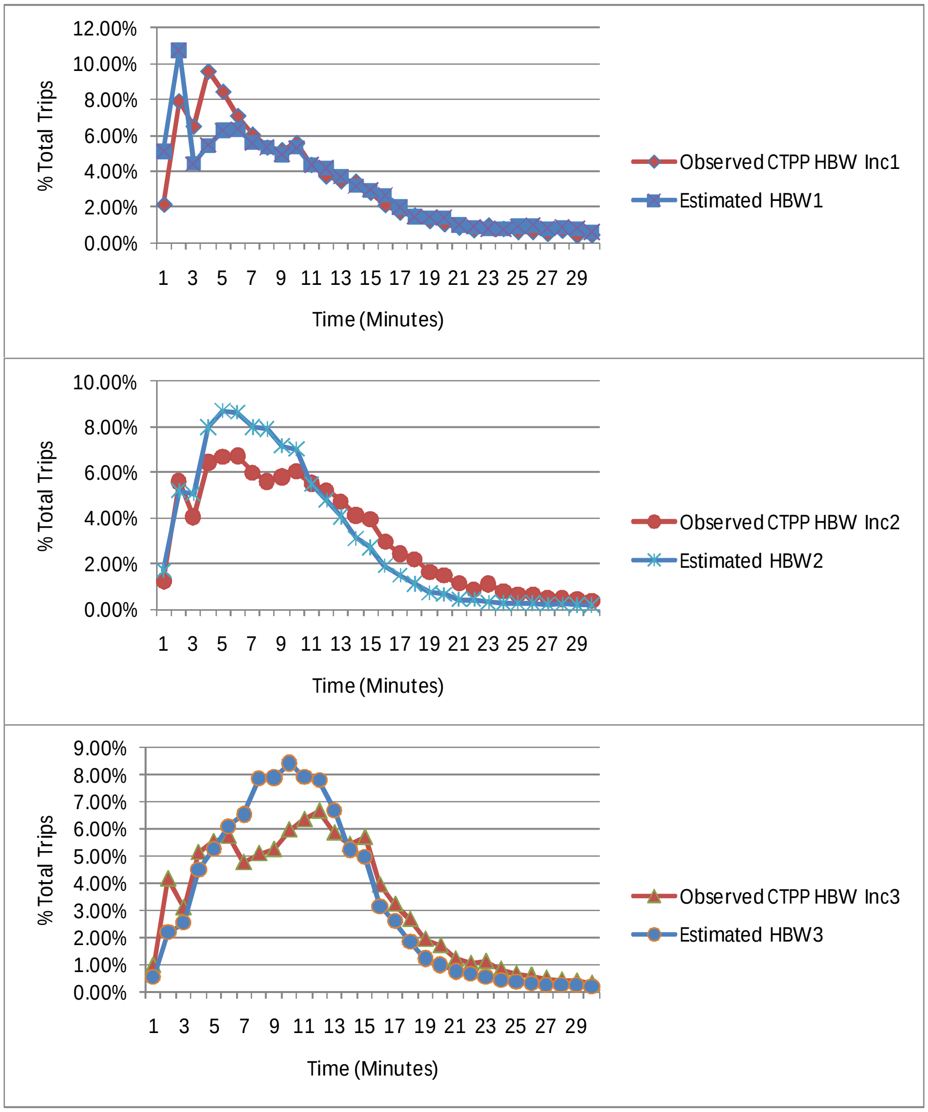
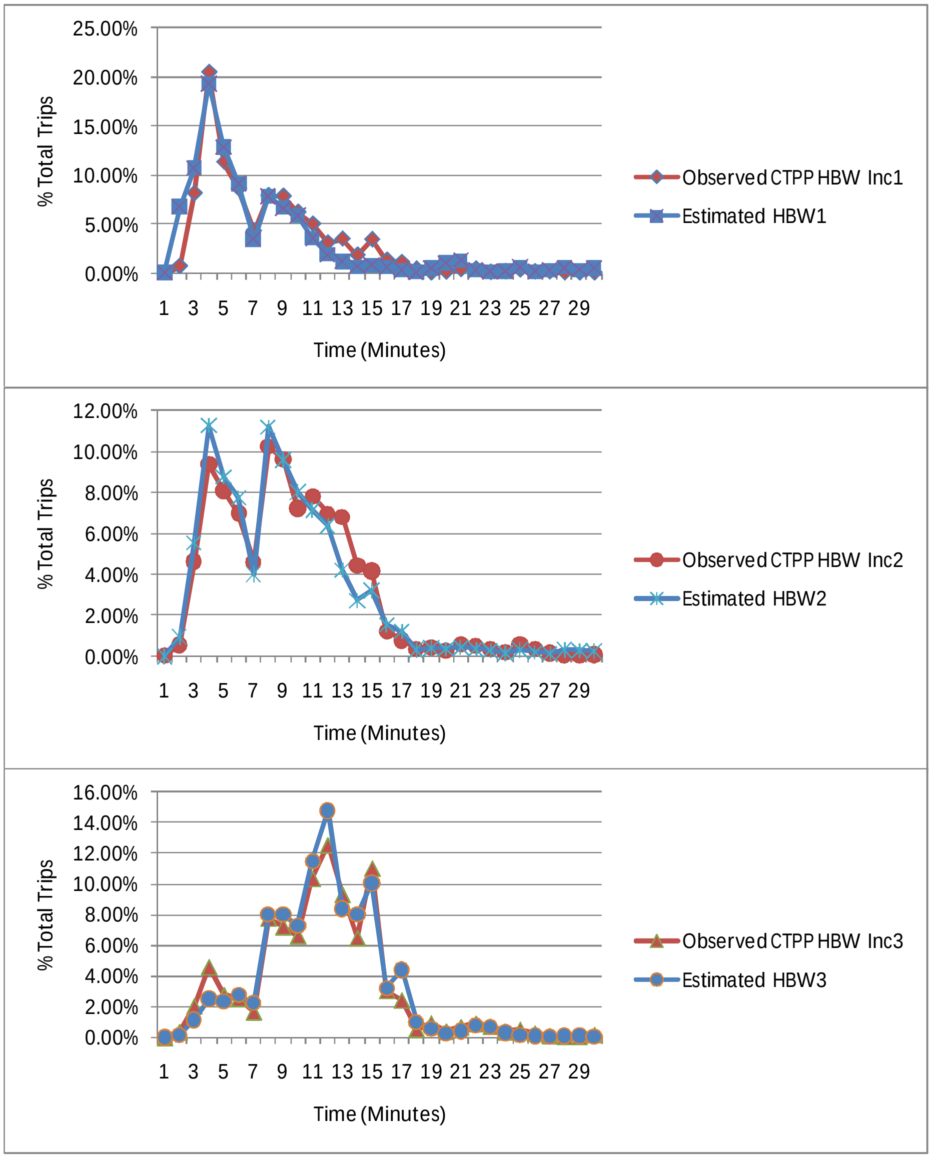


Figure 14 – Home-Based Work Trip Length Frequency Distribution - Corridor to CBD, by income




The trip length evaluation suggested that the model friction factors were adequate, for the purpose of our study, without adjustments.

Additional trip distribution comparisons were made in the study area corridors. District to district movements by trip purpose were assessed. HBW trips were further split into income groups for the comparison.

Table 14 illustrates the trip comparisons from district to district for the HBW Income 1 (Household income below $25,000 annually). Since the primary concern of this study was the distribution of work trips from the study area, K-factors were added on a district level for trips to the CBD, Crown Center, and Plaza to adjust distribution as needed.

Table 14 - Observed Home-Based Work District-to-District Trips, Income 1

| CTPP JTW Tours OBSERVED | CBD | Crown Center | Plaza | SUM | Overall Share |
|---|---|---|---|---|---|
| CBD | 328 | 99 | 83 | 510 | 0.45% |
| Crown Center | 82 | 214 | 51 | 347 | 0.31% |
| Plaza | 171 | 359 | 951 | 1481 | 1.31% |
| Independence | 391 | 421 | 157 | 969 | 0.86% |
| Blue Springs | 133 | 84 | 46 | 263 | 0.23% |
| Raytown | 115 | 126 | 90 | 331 | 0.29% |
| NE Jackson Co | 7 | 8 | 7 | 22 | 0.02% |
| Lafayette Co | 29 | 18 | 10 | 57 | 0.05% |
| Lee's Summit | 67 | 44 | 10 | 121 | 0.11% |
| Cass Co / Johnson Co | 47 | 24 | 27 | 98 | 0.09% |
| Inner Core S | 345 | 400 | 187 | 932 | 0.83% |
| Inner Core N | 594 | 451 | 218 | 1263 | 1.12% |
| SUM | 2,309 | 2,248 | 1,837 | 6,394 | 5.68% |
| Overall Share | 2.05% | 2.00% | 1.63% | | 112,647 |

Table 15 - Initial Modeled Home-Based Work District-to-District Trips, Income 1

| Initial MODELED | CBD | Crown Center | Plaza | SUM | Overall Share |
|---|---|---|---|---|---|
| CBD | 778 | 83 | 14 | 875 | 0.40% |
| Crown Center | 169 | 586 | 51 | 806 | 0.36% |
| Plaza | 82 | 94 | 854 | 1030 | 0.47% |
| Independence | 882 | 653 | 253 | 1788 | 0.81% |
| Blue Springs | 49 | 46 | 24 | 119 | 0.05% |
| Raytown | 118 | 106 | 115 | 339 | 0.15% |
| NE Jackson Co | 15 | 14 | 8 | 37 | 0.02% |
| Lafayette Co | 94 | 84 | 50 | 228 | 0.10% |
| Lee's Summit | 5 | 5 | 8 | 18 | 0.01% |
| Cass Co / Johnson Co | 11 | 10 | 17 | 38 | 0.02% |
| Inner Core S | 552 | 567 | 385 | 1504 | 0.68% |
| Inner Core N | 1769 | 1005 | 318 | 3092 | 1.40% |
| SUM | 4,524 | 3,253 | 2,097 | 9,874 | 4.47% |
| Overall Share | 2.05% | 1.47% | 0.95% | | 221,082 |

Table 16 - Final Modeled Home-Based Work District-to-District Trips, Income 1

| Final Revised MODELED | CBD | Crown Center | Plaza | SUM | Overall Share |
|---|---|---|---|---|---|
| CBD | 794 | 81 | 14 | 889 | 0.40% |
| Crown Center | 179 | 577 | 51 | 807 | 0.36% |
| Plaza | 86 | 92 | 858 | 1036 | 0.47% |
| Independence | 812 | 574 | 255 | 1641 | 0.74% |
| Blue Springs | 93 | 80 | 22 | 195 | 0.09% |
| Raytown | 165 | 140 | 113 | 418 | 0.19% |
| NE Jackson Co | 48 | 41 | 7 | 96 | 0.04% |
| Lafayette Co | 220 | 186 | 51 | 457 | 0.21% |
| Lee's Summit | 13 | 11 | 8 | 32 | 0.01% |
| Cass Co / Johnson Co | 28 | 23 | 16 | 67 | 0.03% |
| Inner Core S | 669 | 644 | 375 | 1688 | 0.76% |
| Inner Core N | 1361 | 872 | 338 | 2571 | 1.16% |
| SUM | 4,468 | 3,321 | 2,108 | 9,897 | 4.48% |
| Overall Share | 2.02% | 1.50% | 0.95% | | 221,104 |

Transit trip distribution was also examined, in particular to the major transit destinations – CBD, Crown Center and the Plaza area. Peak Period transit trips are associated with home-based work transit trips in the model. Table 17 shows the initial and final estimated transit trips to these core work/peak destinations.

| **Peak Trips** | From Corridor | |
|---|---|---|
| | Obs | Est |
| To CBD | 3,580 | 4,285 |
| To Crown Center | 2,264 | 2,878 |
| To Plaza | 1,011 | 1,244 |
| To Westport | 971 | 504 |
| Total | 7,826 | 8,910 |

Figure 15 shows the work/peak transit trip distribution comparison by district to each of the major work destinations.

Trips from the inner core districts to the CBD are overestimated. The adjustment made to the mode choice model to increase transit ridership from zones with very high 0-auto ownership, while improving specific route ridership in the corridor, accentuated the model distribution of transit trips from those zones. This resulted in more ridership from these zones to the CBD

Table 17 – Work/Peak Transit Trip Distribution from the Study Corridor

| **Peak Trips** | From Corridor | |
|---|---|---|
| | Obs | Est |
| To CBD | 3,580 | 4,285 |
| To Crown Center | 2,264 | 2,878 |
| To Plaza | 1,011 | 1,244 |
| To Westport | 971 | 504 |
| Total | 7,826 | 8,910 |

Figure 15 – Work/Peak Transit Distribution

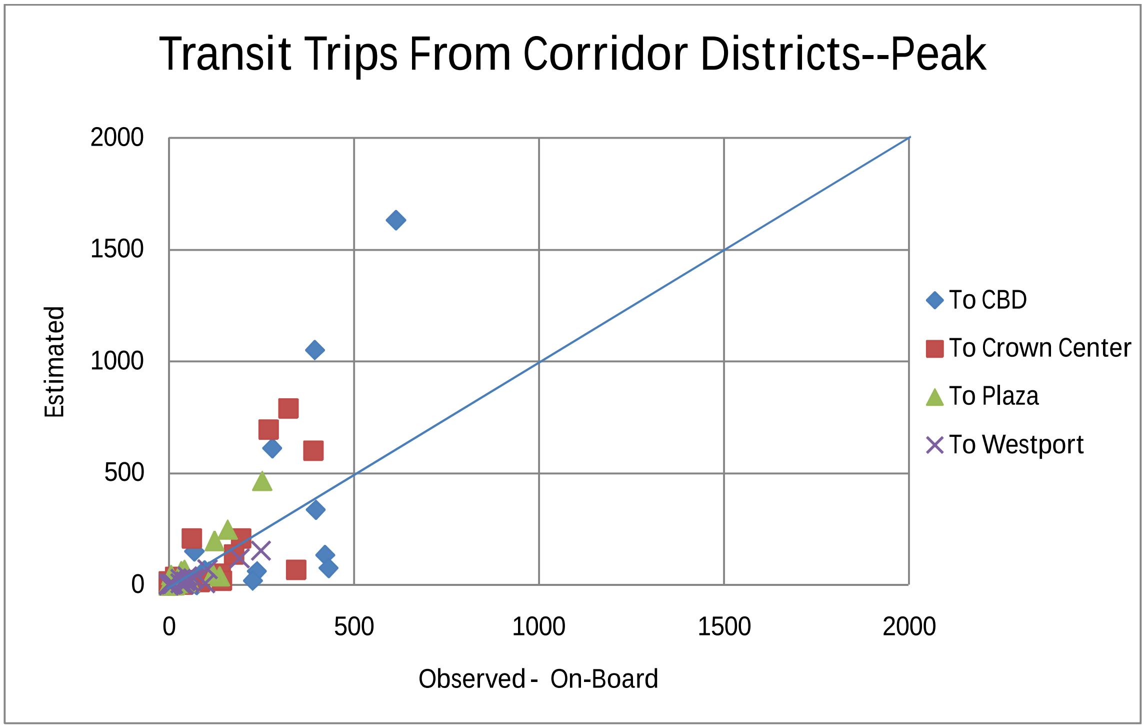
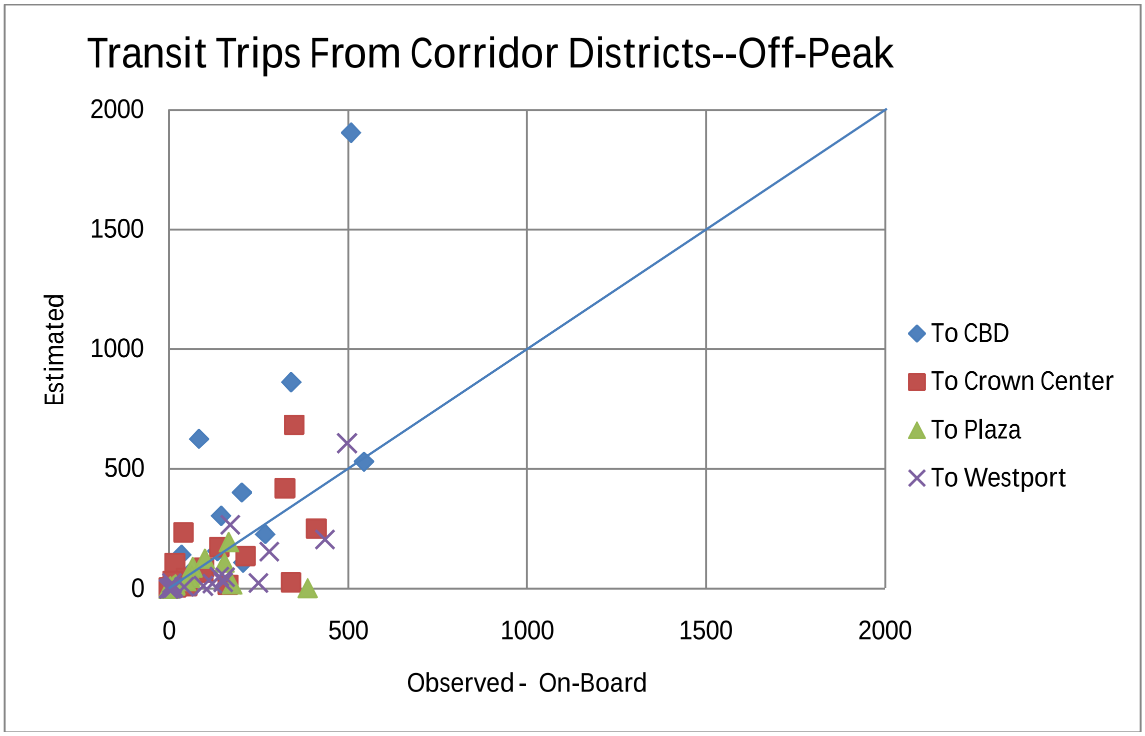



Table 18 shows the initial and final estimated off-peak transit trips to the core work destinations. Figure 16 shows the off-peak transit distribution comparison by district to each of the major work destinations. Trips from the inner core districts to the CBD are overestimated here. This is also an effect of including the 0-auto constant in the mode choice model.

Table 18 – Non-Work/Off-Peak Transit Distribution

| **Off-Peak Trips** | From Corridor | |
|---|---|---|
| | Obs | Est |
| To CBD | 2,657 | 5,463 |
| To Crown Center | 2,314 | 2,269 |
| To Plaza | 1,278 | 721 |
| To Westport | 2,254 | 1,435 |
| Total | 8,503 | 9,889 |

Figure 16 – Non-Work/Off-peak Transit Distribution




## Mode Choice

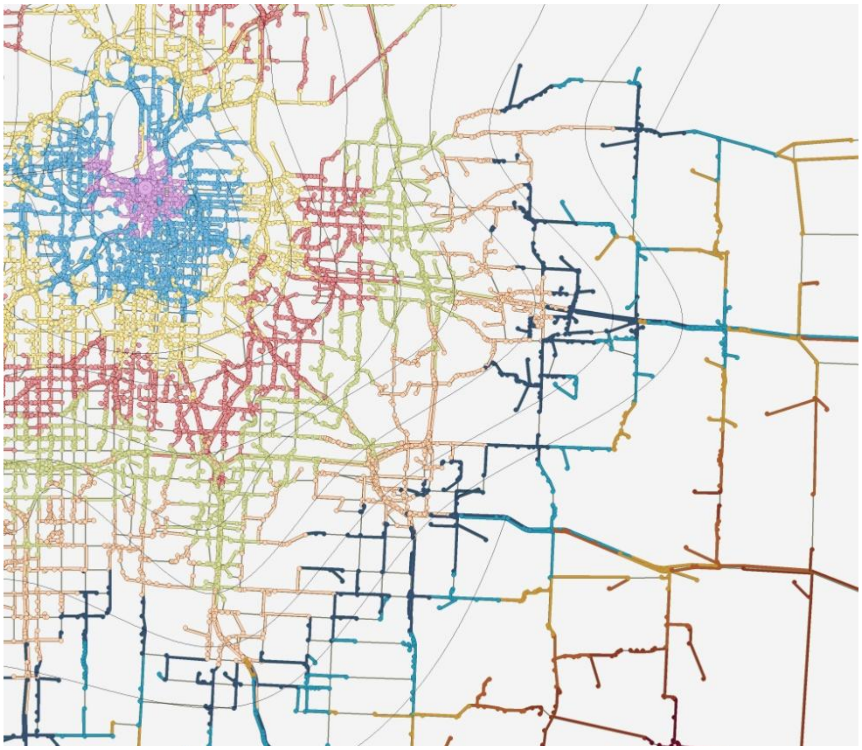
In order to accurately calibrate the mode choice model, an updated base year was required.

### 2010 Base Year

Because BRT busses were introduced in 2008, a BRT mode was added to the model. In order to calibrate this new mode, a 2010 model was created. The 2010 socioeconomic dataset and network was provided by MARC. Observed BRT trip tables were created from the MAX On-Board survey in 2008.

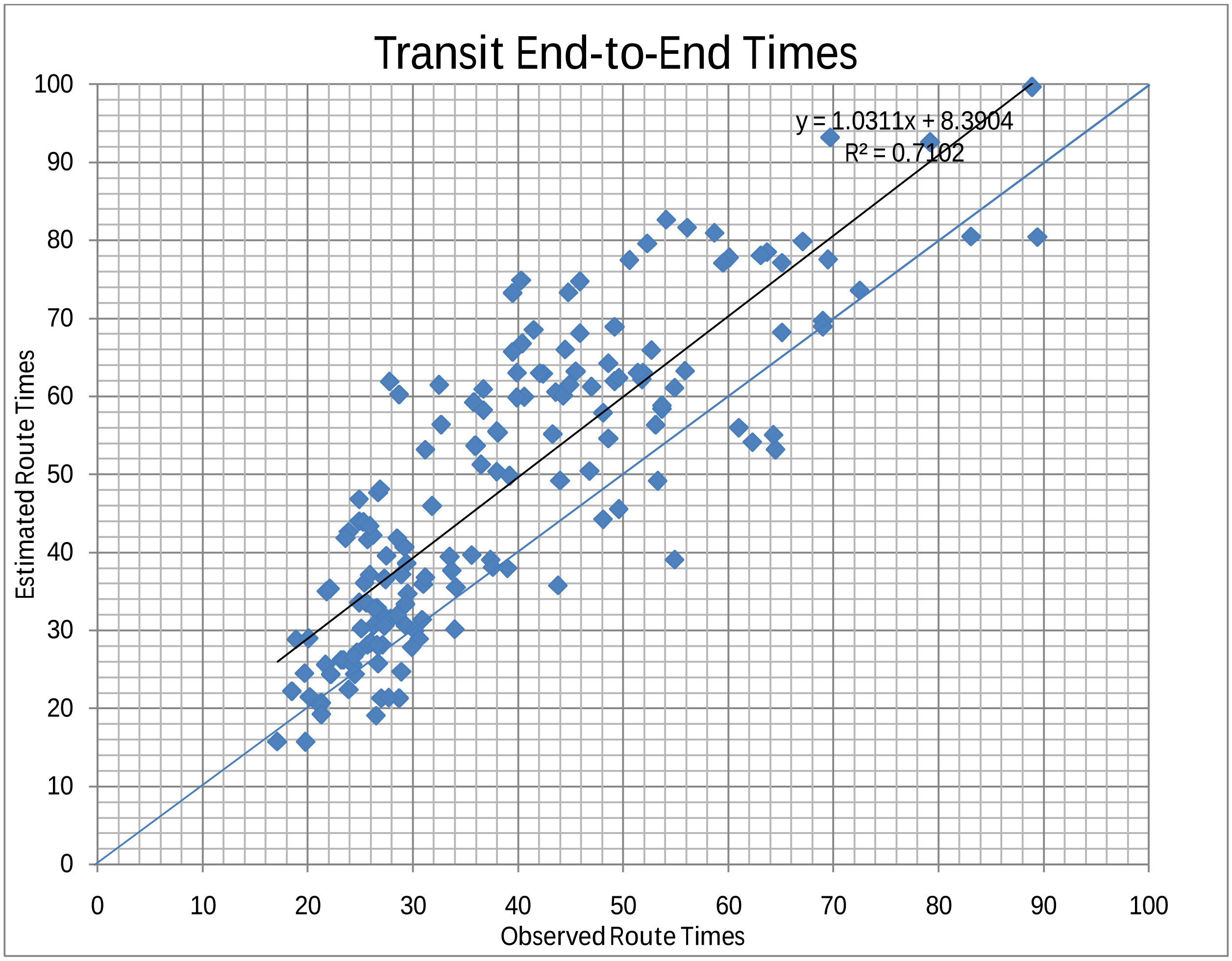
A comparison of the 2010 travel times was performed using 2010 INRIX data provide by MARC to compare against the 2010 modeled travel times. The resulting analysis resulted in the volume delay functions being adjusted to better fit the observed speeds on highways and arterials. It also resulted in the peak hour skim definitions being changed from an average of the 8AM and 9AM travel times, to using the 7AM travel time, which reflected the speeds shown in the observed data more closely.

Figure 17 - 7-8AM Travel Time, 10min Contours, INRIX Overlay



2010 Transit line revisions to headways to reflect 2010 conditions were made, as needed. Dwell times were also reviewed and adjusted to better match end to end running times. Figure 18- 2010 Peak Transit Travel TimesFigure 18 shows a travel time comparison between observed times and estimate times.

Figure 18- 2010 Peak Transit Travel Times




For 2010, the mode choice model was heavily modified to better capture the new modes and reflect the diverse transit markets in the study area.

Three initial modifications were implemented to improve the mode choice model:

1. The skim procedure was modified such that the shortest-path algorithm performed better. This was done by adding a spread factor of .01 into the skimming routine for non-local bus modes. Local bus-favored skims were left with the default spread factor of 1. This was to improve ridership on the south-central routes, especially Route 71.
2. Path building routines were evaluated by mode. From this analysis, we determined that there was a need to include more access links such that all modes had sufficient access to surrounding zones. Mode specific connectors are now generated for BRT, LRT, and CRT modes. Park and ride connections were split on the Kansas and Missouri sides of the state line, and the Kansas connector links were shortened to reflect observed.
3. Boarding penalties were also adjusted to modify the transfer rates to match observed rates by mode.

Four specific tools were added to the mode choice to improve the calibration of the additional modes.

1. A distance stratification option was added but not used.

2. An in-vehicle time to access time ratio function was included to avoid trips that had very long drive access times but very short actual transit in-vehicle times.
3. A district specific factor was introduced. This could be used to boost the appeal of transit heavy districts. This was a positive constant added to districts like the CBD, Plaza, and Crown Center.
4. A 0-Auto household factor was also introduced. This function is a piecewise-linear function for households with 0-auto ownership below a user-specified input. This greatly improved route ridership comparisons for Route 71, which serves a particularly auto-dependent area.

Though not directly related to the validation, the mode choice model was also enhanced to incorporate commuter rail and BRT modes, and functionality to incorporate an in-vehicle time discount was also added.

## Assignment

Highway assignment procedures were reviewed. The routines were updated to use the EMME parallel assignment procedure for quicker computation times. The closure criteria were also updated for all highway assignments for consistency throughout the model process. The new criteria also better reflect current best practices to reduce model noise outside the study area. New closure criteria, compared to the originals are shown in Table 19.

Table 19 - Highway Assignment Closure Criteria

| | MARC Model (varied) | JCCCAA Model |
|---|---|---|
| Iterations | 20 - 50 | 100 |
| Best Relative Gap | .5 - .1 | 0.01 |
| Normalized Gap | .1 - .05 | 0.01 |

The transit assignment procedure was updated into separate assignment routines by mode. It also included a spread factor of .01 for non-local bus paths. Assignment results were compared to On-Board survey results and KCATA fare-box data, shown in Table 20.

Table 20 - KCATA Transit Assignment Comparison – Year 2010

| KCATA ROUTES | KCATA Daily Average | On-Board Survey Records | Model Initial Transit Asgn | Model Final Transit Asgn |
|---|---|---|---|---|
| #12 Twelfth Street | 1,687 | 2,152 | 2,139 | 3,682 |
| #24 Independence | 3,263 | 3,633 | 2,702 | 4,235 |
| #25 Troost | 7,604 | 8,487 | 1,605 | 3,707 |
| #27 Twenty-seventh Street | 641 | 1,084 | 150 | 412 |
| #28 Blue Ridge | 2,072 | 2,189 | 4,621 | 2,888 |
| #30 Northeast | 667 | 1,057 | 1,705 | 2,135 |
| #31 Thirty-first Street | 1,944 | 2,632 | 155 | 1,138 |
| #35 35th Street | 676 | | 506 | 706 |
| #37 Gladstone | 95 | | 300 | 213 |
| #38 Meadowbrook | 222 | 350 | 748 | 839 |

| KCATA ROUTES | KCATA Daily Average | On-Board Survey Records | Model Initial Transit Asgn | Model Final Transit Asgn |
|---|---|---|---|---|
| #39 Thirty-ninth Street | 3,070 | 4,439 | 1,316 | 2,204 |
| #47 Roanoke | 1,360 | 1,127 | 1,191 | 819 |
| #51 Broadway | 1,149 | 1,685 | 1,129 | 2,075 |
| #53 Armour/Swope Park | 983 | 1,309 | 1,006 | 785 |
| #54 Armour/Paseo | 1,108 | 1,394 | 1,177 | 912 |
| #55 Rockhill | 102 | 205 | 136 | 130 |
| #56 Country Club | 43 | | 0 | 0 |
| #57 South Oak | 1,029 | 1,282 | 809 | 872 |
| #58 MAX | 4,131 | 3,331 | 3,322 | 3,580 |
| #69 Liberty Express | 95 | 103 | 78 | 82 |
| #71 Prospect | 5,404 | 6,158 | 1,058 | 3,449 |
| #101 Minnesota | 1,463 | 1,128 | 3,172 | 1,965 |
| #102 Central | 81 | 311 | 411 | 539 |
| #104 Argentine | 363 | 451 | 166 | 271 |
| #106 Quindaro | 1,246 | 1,392 | 1,322 | 2,297 |
| #107 Seventh St/Parallel | 547 | 630 | 935 | 259 |
| #108 Indiana | 1,054 | 1,218 | 948 | 421 |
| #109 Ninth Street | 345 | 432 | 729 | 208 |
| #110 Woodland/Brooklyn | 136 | | 312 | 424 |
| #121 Cleveland | 508 | 111 | 263 | 382 |
| #123 Twenty-third Street | 132 | | 312 | 188 |
| #126 East Fifth Street | 82 | | 196 | 170 |
| #129 I-29 Express | 547 | 371 | 810 | 1,010 |
| #132 Gracemor | 38 | | 86 | 123 |
| #133 Vivion/Antioch | 234 | | 633 | 608 |
| #135 Winnwood/69 Hwy | 34 | | 158 | 75 |
| #136 Boardwalk/Antioch | 38 | 58 | 44 | 48 |
| #137 Metro North/Antioch | 61 | | 82 | 205 |
| #142 North Oak | 763 | 338 | 754 | 627 |
| #152 LS/Raytown Express | 210 | 113 | 125 | 110 |
| #155 Fifty-fifth Street | 206 | | 334 | 72 |
| #156 Red Bridge Connector | 495 | 439 | 1,644 | 430 |
| #163 Sixty-third Street | 657 | 699 | 385 | 322 |
| #170 Blue Springs | 268 | | 157 | 108 |
| #173 Casino Cruiser | 715 | 1,163 | 330 | 522 |
| #175 Seventy-fifth Street | 735 | 377 | 1,445 | 467 |
| #183 Green Independence | 199 | | 98 | 257 |
| #229 I-29/Tiffany Springs | 150 | | 21 | 37 |
| #237 Gladstone Circulator | 18 | | 384 | 431 |

| KCATA ROUTES | KCATA Daily Average | On-Board Survey Records | Model Initial Transit Asgn | Model Final Transit Asgn |
|---|---|---|---|---|
| #243 Antioch/Barry Conn. | 80 | | 163 | 104 |
| #244 NKC Circulator | 61 | | 50 | 85 |
| #247 Westside Circulator | 37 | | 32 | 1 |
| #251 TMC Lakewood Conn | 66 | | 279 | 144 |
| #252 Lee's Summit Circ. | 25 | | 85 | 78 |
| #253 Raytown Circulator | 91 | | 487 | 325 |
| #284 Purple Independence | 120 | 139 | 152 | 182 |
| #285 Blue Independence | 121 | 149 | 285 | 144 |
| #286 Silver Independence | 11 | | 0 | 0 |
| #291 Yellow Independence | 83 | | 82 | 20 |
| #292 Orange Independence | 99 | 140 | 78 | 71 |
| #293 Red Independence | 122 | | 59 | 91 |
| #296 Bannister/Loma Vista | 136 | | 38 | 209 |
| #298 SKC Wornall | 84 | | 97 | 95 |
| #471 71 Hwy Express | 220 | | 88 | 80 |
| TOTAL | 50,026 | 52,277 | 44,084 | 49,068 |

Figure 19 - 2010 Daily Ridership Comparison by Route